Restoration Plan for the Rainbow Springs and River
DRAFT

Prepared For

Florida Department of Environmental Protection
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Acknowledgments

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Thank you to Dr. Matt Cohen and Dr. Andrea Albertin at the University of Florida for their invaluable support, input, and guidance throughout the development of the draft Restoration Plan and for their commitment to understanding our springs systems through scientific research.

The Rainbow Springs Basin Working Group has been fortunate to have many passionate and hard-working people dedicated to protecting and restoring Rainbow Springs and River over many decades. It is through their support that many successes have been made. And it is through their vision that we hope to restore and protect the Rainbow Springs and River.

Thanks to everyone for a job well done.

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Acronyms and Abbreviations

AWT	advanced wastewater treatment
BMAP	basin management action plan
BMPs	best management practices
cfs	cubic feet per second
CR	county road
DO	dissolved oxygen
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOF	Florida Division of Forestry
FGS	Florida Geological Survey
FORS	Friends of Rainbow Springs State Park
FOWA	Florida Onsite Wastewater Association
FWC	Fish and Wildlife Conservation Commission
gpcd	gallons per capita per day
MCAVA	Marion County Aquifer Vulnerability Assessment
MCPR	Marion County Parks and Recreation
MFL	minimum flow and level
mg/L	milligram per liter
mgd	million gallons per day
MSWCD	Marion Soil and Water Conservation District
N	nitrogen
OSDS	onsite sewage disposal system
P	phosphorous
ppm	parts per million
RIB	rapid infiltration basin
RSBWG	Rainbow Springs Basin Working Group
RSSP	Rainbow Springs State Park
SAV	submerged aquatic vegetation
SJRWMD	St. Johns River Water Management District
SPZ	springs protection zones
sq mi	square mile
SRSP	Silver River State Park
SSBWG	Silver Springs Basin Working Group
STA	stormwater treatment area
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TDS	total dissolved solids
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WAM	Watershed Assessment Model
WRAMS	Water Resources Assessment and Management Study
WRWSA	Withlacoochee Regional Water Supply Authority
WWTP	wastewater treatment plants
µg/L	microgram per liter
USGS	United State Geological Survey

1 Executive Summary (to follow)

2 Background

2.1 Overview of Rainbow Springs and the Rainbow River

Rainbow Springs is a first-magnitude springs system located in southwest Marion County, approximately 4 miles north of Dunnellon and 20 miles southwest of Ocala (**Figure 2-1**). A minimum of 10 named springs with a collective average discharge of 685 cfs (cubic feet per second) or 443 mgd (million gallons per day) make up the Rainbow Springs Group and give rise to the Rainbow River (USGS Discharge Record 1965-present: http://fl.water.usgs.gov). The river flows south from the head springs for approximately 5.7 miles until it joins the Withlacoochee River, and numerous springs discharge into the riverbed along its entire length (Champion and Starks 2001).

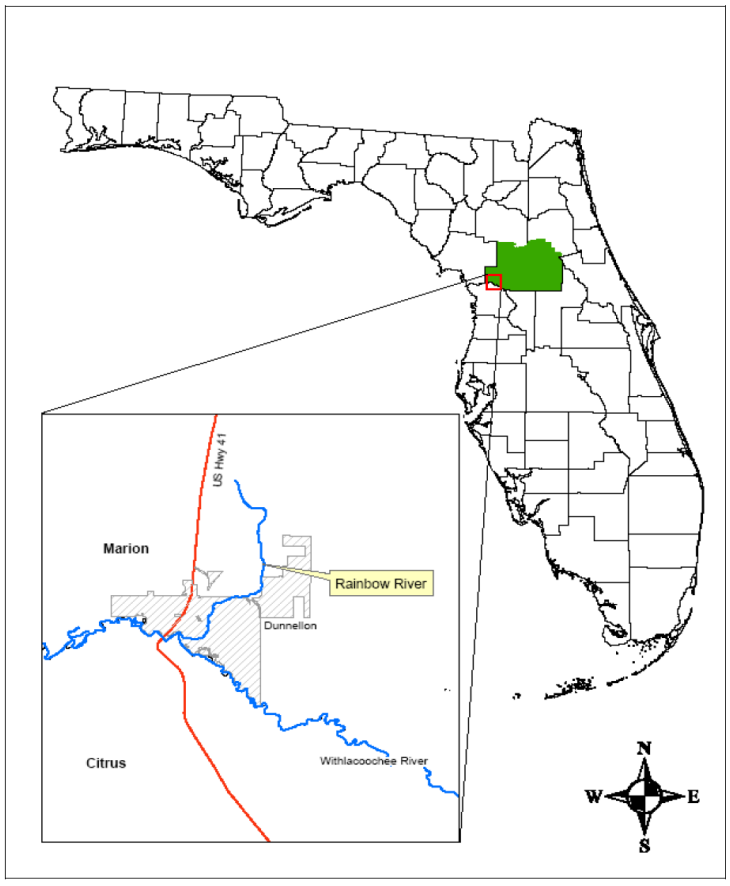


Figure 2-1. Location of the Rainbow River.
Source: SWFWMD 2008

Rainbow Springs receives groundwater from a basin of approximately 700 sq mi (square miles) that includes most of Marion County west of Interstate 75, most of southeastern Levy County east of Goethe State Forest, and a small section of southern Alachua County. Williston is the only sizable community in the springs basin, with the City of Dunnellon just south of the basin.

Most of the land use within the springs basin is agricultural, especially equine. Significant development is occurring within 10 miles of the head springs just north of Dunnellon. Most of the western shore of the river is developed with houses and docks and one or two restaurants while most of the eastern shore is undeveloped with riparian and floodplain forest.

In an effort to encourage the preservation of Rainbow Springs, the National Park Service designated the Rainbow Springs Group as a National Natural Landmark in 1972. In 1986, the Florida legislature established the springs and river as the Rainbow Springs Aquatic Preserve to be managed by the Florida Department of Environmental Protection (FDEP), and the river was declared an Outstanding Florida Water in 1987 (SWFWMD 2008). The Rainbow Springs State Park was created in 1995 and surrounds the head springs and large portions of the eastern bank of the Rainbow River (SWFWMD 2004). The preserve and park receive over 200,000 visitors per year with 213,780 visitors reported for 2009/10. The principal recreational activities engaged in at the park include swimming, hiking, sightseeing, tubing, camping and canoeing.

3 Planning Process

3.1 Description of Working Groups

Between July 2010 and June 2011, the Rainbow Springs Basin Working Group (RSBWG) focused on developing a draft Restoration Plan for the Rainbow Springs and River.

The draft Restoration Plan has been developed through discussion, cooperation, and consensus among a broad range of stakeholders. A stakeholder is self-described as an individual who cares about the future of the Rainbow Springs and River. The RSBWG stakeholder list has 253 individuals on it including representation of a broad range of agencies, organizations, and citizens. The list is updated regularly, especially after each quarterly meeting, based on referrals and also based upon requests from stakeholders to be added. Stakeholders participated in the planning process through, four quarterly meetings, several planning meetings, individual meetings, phone calls, and email communications. Email updates were sent to stakeholders periodically to announce news of interest, to summarize the status of the planning process, and to provide important information about meetings, events, issues, news articles, and funding opportunities that relate to the Rainbow Springs and the springs basin.

Stakeholders that have participated in the process include:

- Florida Department of Environmental Protection: (Florida Park Service, Groundwater Programs, Ocklawaha and Rainbow River Aquatic Preserve, Bureau of Mining & Minerals)
- Southwest Florida Water Management District (SWFWMD)
- Florida Geological Survey (FGS)
- Florida Division of Forestry (FDOF)
- Florida Fish and Wildlife Conservation Commission (FWC)
- Florida Department of Agriculture and Consumer Services (FDACS)
- University of Florida, School of Forestry and Conservation
- Marion County: (Water Resources Coordinator, Parks and Recreation, Extension, Soil and Water Conservation Service, Planning)

- City of Ocala (Water and Sewer)
- City of Dunnellon (Planning and City Council)
- Florida Springs Institute
- Withlacoochee Regional Planning Council
- Rainbow River Conservation
- Suwannee St. Johns Sierra Club
- Ocklawaha Valley Audubon Chapter
- Florida Onsite Wastewater Association (FOWA)
- Friends of Rainbow Springs State Park (FORS)
- Friends of the Marion Environment
- Gissy Springs
- Representatives of several private companies: (Aquapure, Inc., Biofilters Inc., Hydro Consultants, Wetland Solutions, Inc., Wild Florida Adventures, and HydroMentia, Inc.)
- Two golf courses: (Rainbow's End and Juliette Falls)
- An independent hydrogeologist
- Assorted citizens

The planning process began with a joint meeting with the Silver Springs Basin Working Group (SSBWG) to decide upon the priorities and sideboards for both planning processes. Out of this meeting came the primary categories for goal setting as follows:

- Biodiversity
- Education and Outreach
- Land Use and Development
- Recreation (particularly important for Rainbow)
- Water Quality
- Water Quantity (Spring Flow)

3.2 Meeting Summaries

Over the course of the year, four quarterly working group meetings were held as well as numerous planning and stakeholder meetings that were both in-person and over the phone.

Table 3-1. Working Group Meetings August 2010 – June 2011

Month	Type of Meeting	Description
August	Quarterly	First Stakeholder Quarterly Meeting – Jointly held with SSBWG
September	Planning	Meeting with Marion County Staff (City Engineer, Growth Management, Utilities)
September	Planning	Meeting with SWFWMD staff from several departments
November	Quarterly	Second Quarterly Meeting – working session on developing the Vision
December	Planning	Meeting with Coordinating Group for the Working Group to discuss strategies
December	Planning	Meeting with Agricultural Stakeholders to discuss Ag land users, nitrate loading and BMPs

Table 3-1. Working Group Meetings August 2010 – June 2011

Month	Type of Meeting	Description
Nov- Jan	Planning	Preparatory and follow up phone discussions with meeting participants for the agricultural stakeholders planning meeting
January	Quarterly	Third Quarterly Meeting for Goal Setting
March	Planning	Meeting with 3 golf courses superintendents to discuss golf course management
Feb-March	Planning	Numerous calls to various people associated with golf course and turf grass management
March	Planning	Meeting with Ocala Marion Chamber of Commerce Director to discuss economic value of the springs
April	Quarterly	Fourth Quarterly Meeting to continue Goal Setting
April	Planning	Meeting with Levy County and City of Williston Officials to discuss Restoration Plan
April - June	Planning	Numerous short meetings with stakeholders organized into goal setting groups to discuss progress towards development of goals and actions
May	Planning/ relationship building	Attended Field Day on golf course management at the UF turf grass research facility in Citra

3.3 Plan Refinement and Implementation

At this time, it is uncertain what the future holds for the Rainbow Springs Basin Working Group. Funding for coordination of the group has been cancelled for 2011-12. The planning process was to continue into year 2 and also restoration actions were to be encouraged.

In an effort to determine how the RSBWG can be more effective, Dr. Martha Monroe of the University of Florida implemented a stakeholder survey. The survey has been distributed via email to the stakeholders, and results will eventually be shared with the coordinator. An additional survey of the public during 2011-12 is planned to determine attitudes about springs protection. This should inform educational efforts.

During 2011-12 it will be important for all stakeholders to unite around the Restoration Plan's goals and to refine the actions and the responsibility for each action. Without leadership and coordination, this effort will be difficult. A mechanism to maintain the RSBWG's coordination function would therefore be advantageous. It should be noted that both a Total Maximum Daily Load (TMDL) and a Minimum Flows and Levels (MFLs) process will be implemented in the upcoming months and years and both will require public input. Following the TMDL will be a Basin Management Action Plan (BMAP) process, also needing public input. The existing Springs Working Group infrastructure (coordinator, stakeholder contact list, local knowledge of the players, meeting structure, etc., could all play a supporting role to the TMDL and MFLs processes. Both processes represent significant aspects of the restoration effort and are supported by goals in the Restoration Plan. A shared funding mechanism between FDEP, the appropriate water management districts, plus county and city governments could maintain the basic elements

of the RSBWG and allow the agencies to move smoothly into the public input process for their regulatory processes.

With this in mind, the following goal for the Rainbow Springs Basin Working Group for Fiscal Year 2012 is offered.

Goal 1. Coordinate restoration efforts (centered on the TMDL and MFLs processes) with all stakeholders to avoid duplication and consolidate and share resources effectively.

Actions

1. Maintain a stakeholder email list with representatives from all key agencies and organizations.
2. Provide mechanisms for sharing information and collaborating among stakeholders.
3. Help identify unifying messages and approaches when possible.
4. Make decisions on restoration actions to implement goals within the Restoration Plan based on priorities, capacities, and costs.
5. Plan ways to implement actions and monitor success.
6. List restoration actions and strategies for tracking potential changes in the system.

4 Physical Description

The Rainbow Springs head springs are made up of a cluster of smaller springs which taken together produce a combined flow of 685 cfs (443 mgd). **Figure 4-1** illustrates the spatial relationship of the named spring vents within the upper reaches of the river and the single tributary, Indian Creek, which has four springs. These springs give rise to the 5.7 mile Rainbow River which joins the Withlacoochee River near Dunnellon.

4.1 The Rainbow Springs Basin

The size of the groundwater recharge area, or springs basin, that feeds the Rainbow Springs Group and Rainbow River varies on a seasonal basis and is delineated using water-level contours representing average potentiometric surface conditions of the Upper Floridan Aquifer (**Figure 4-2**). The Rainbow Springs basin, which borders the Silver Springs basin, covers portions of western Marion, southeastern Levy, and southern Alachua counties. The basin is approximately 700 sq mi in size although according to Jones et al (1996) it expands to approximately 770 sq mi at the end of the wet season in September and shrinks to approximately 645 sq mi at the end of the dry season in May. In contrast, the Rainbow River watershed is approximately 10 times smaller (73 sq mi) and has very little influence on river flow (SWFWMD 2008).

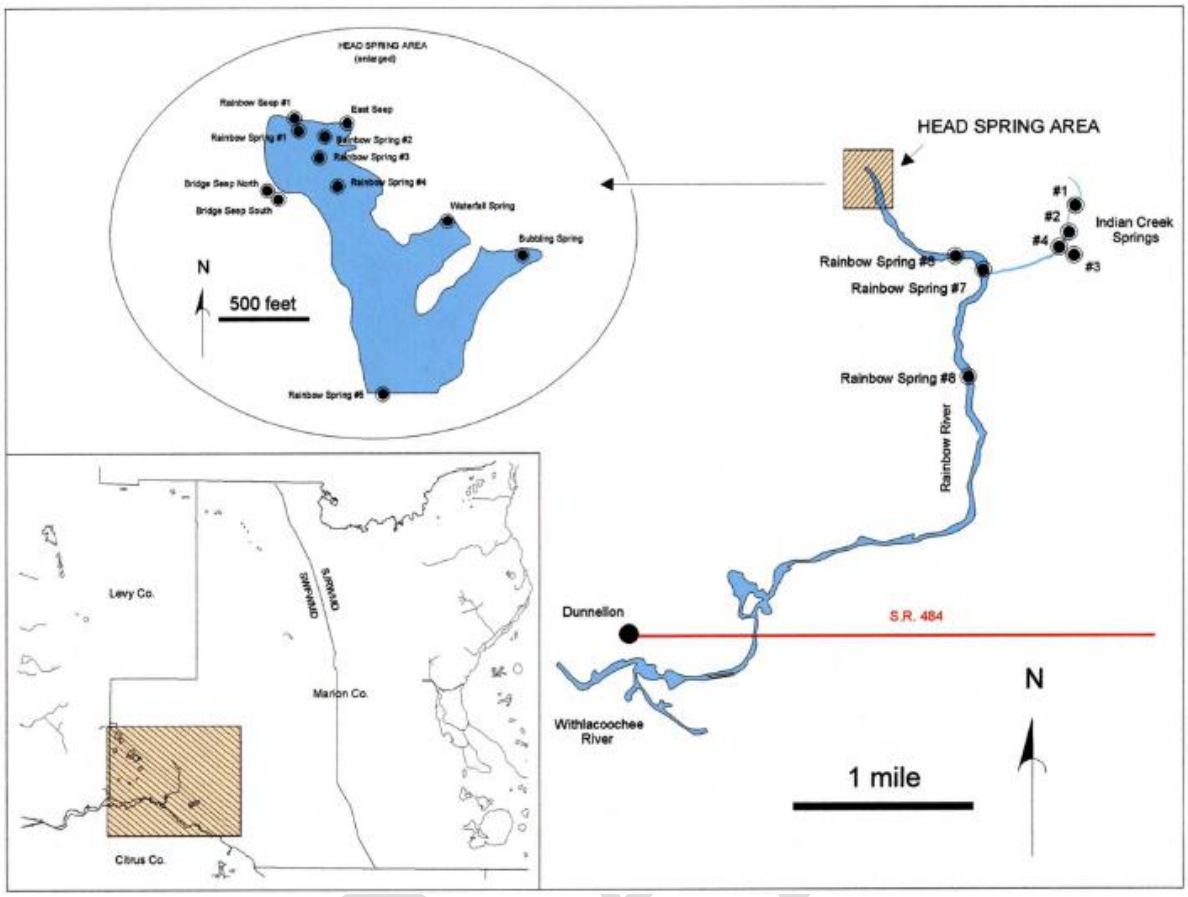


Figure 4-1. Location of named springs in the Rainbow Springs Group.
Source: Champion and Starks 2001

4.1.1 Land use

Land use close by the Rainbow River has undergone numerous changes during the past 130 years. During the 1880s, large portions of the area surrounding the river were logged and planted with citrus. In the 1890s, hard rock phosphate was discovered, and there were dozens of mining operations along the banks of the lower Rainbow River and the Withlacoochee River. Most of the mining operations closed with the advent of World War I and the discovery of pebble rock phosphate in Hillsborough and Polk counties, although some mines continued to operate until 1966 (SWFWMD 2004).

Residential and commercial land use in the Rainbow River watershed (**Figure 4-3** shows the land area of the watershed – about 70 square miles) increased from 64 acres in 1944 to 7,151 acres in 1999, with an additional 10,349 acres platted for development (SWFWMD 2004). Agricultural lands increased from 7,454 acres in 1944 to 18,418 acres in 1999 and forested lands decreased from 36,969 to 9,620 acres during the same time period (SWFWMD 2004).

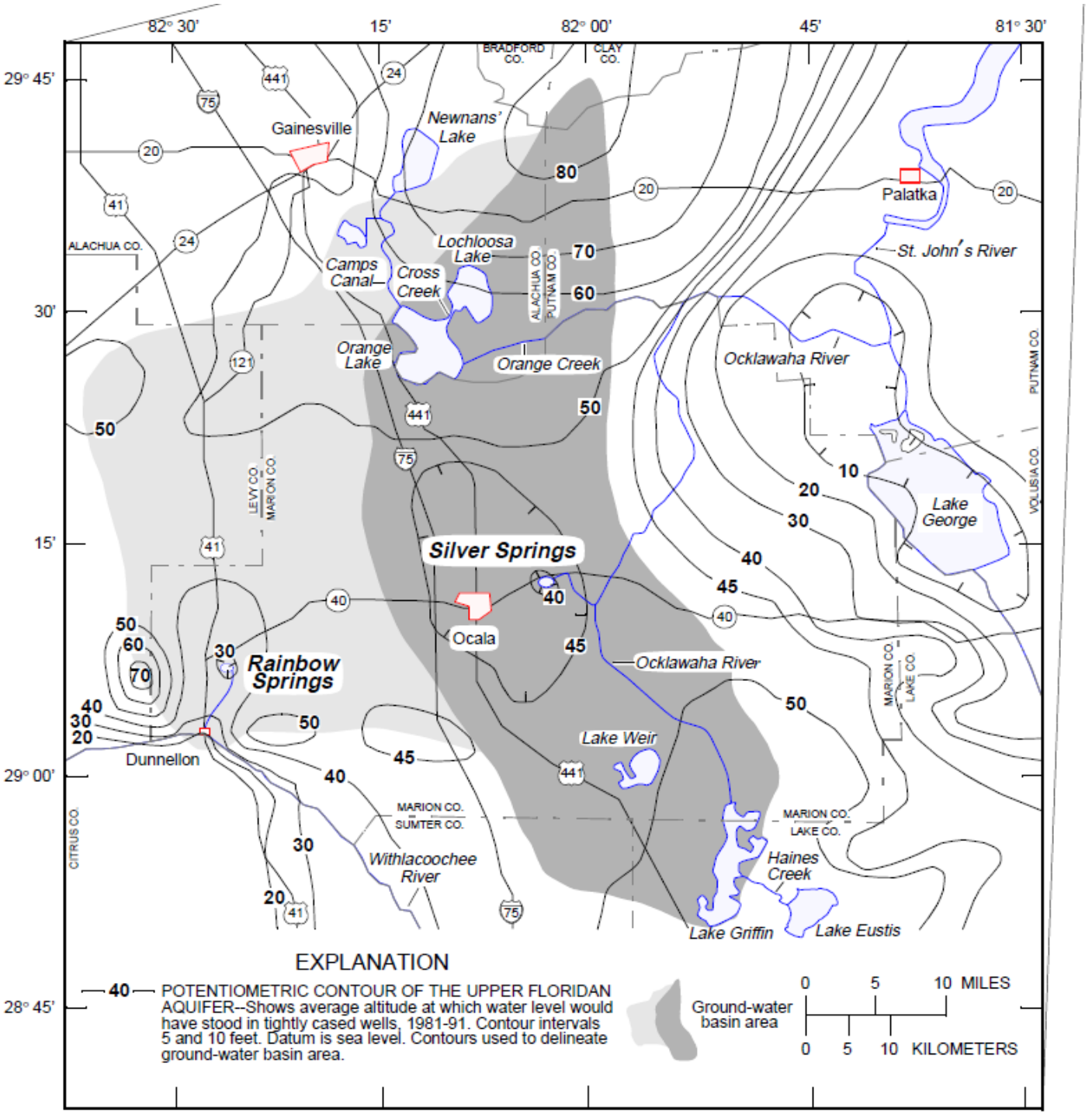


Figure 4-2. Extent of the Rainbow Springs basin. The neighboring Silver Springs basin in also shown.
Source: Knowles 1996

The more than 700 square mile area of the Rainbow Springs basin is primarily rural with agricultural land uses with row crops, pastures and specialty farms dominating (**Figure 4-4**). There is also significant acreage devoted to silviculture. Specialty farms include approximately 200 horse farms largely located in western Marion County. Housing developments have been increasing in recent decades with centers of development in the immediate vicinity of the springs and river, to the north and to the east.

4.1.2 Aquifer vulnerability

The Upper Floridan aquifer within the Rainbow Springs basin is largely unconfined at the surface, and recharge by local rainfall is high in most areas of the basin (>10 in per year) (Faulkner 1970). The Upper Floridan aquifer is approximately 600 ft thick in the Rainbow Springs basin (**Figure 4-5**), and water discharging from the springs comes predominantly from the upper stratum of the aquifer, known as the Ocala Limestone (Knowles 1996). The greatest amount of recharge occurs where the Ocala Limestone is at or near the land surface. The Marion County Aquifer Vulnerability Assessment (MCAVA) conducted by Advanced GeoSpatial Inc. for Marion County provided a relative measure of how rapidly water percolates into the aquifer and indicated that the entire portion of the Rainbow Springs basin located in the county is "vulnerable" to "most vulnerable" (**Figure 4-6)** (Baker and Cichon 2007). A similar assessment, but with slightly different terminology, indicated that eastern Levy County had a "more vulnerable" status, which effectively meant that the aquifer is equally as vulnerable as it is in western Marion County **(Figure 4-7**) (Baker et al 2009).

In areas where the Hawthorn Group sediments cover the limestone and where the Avon Park Formation is near the land surface, recharge is largely concentrated at sinkholes, due to lower rock permeability in these areas. This is the case northwest and southeast of Dunnellon (Knowles 1996). The Avon Park Formation has lower permeability because of sand and clay-filled solution cavities and because of dolomitization (where limestone has been converted to dolomite through the replacement of calcium by magnesium) (Jones et al. 1996).

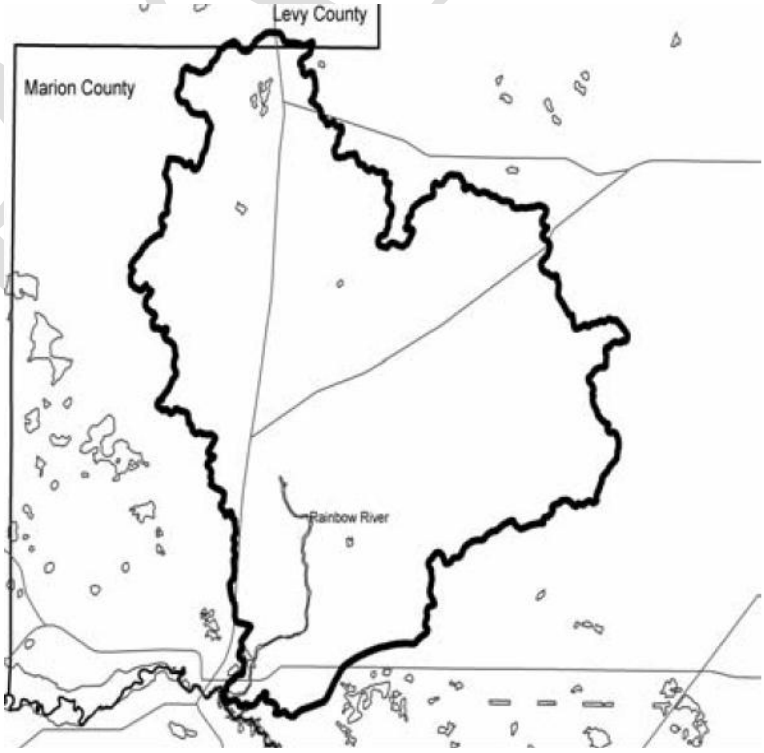


Figure 4-3. Extent of Rainbow River watershed.
Source: SWIM Plan for Rainbow River

Jones et al. (1996) found that the chemistry of the water discharging from the Rainbow Springs Group **indicated that the water moved through** a short, shallow flow system and that much of the water had been in the aquifer for only a few decades. Three prominent fractures traces, indicating possible subsurface fractures in the bedrock, pass through the Rainbow Springs Group and likely serve as conduits for the rapid transport of large quantities of groundwater to the springs (Jones et al. 1996). One fracture trace trends northwest from the springs along the Marion/Levy County line, and another trends northeast from the springs toward Ocala. Tritium studies (a rare isotope of hydrogen, ^{3}H) support the findings that much of the water in the Rainbow Springs basin is relatively young (Faulkner 1970, Swancar and Hutchinson 1992). Faulkner (1970) found that a large portion of the groundwater discharging from both Rainbow and Silver Springs during the period 1966 to 1968 had not been in the aquifer for more than 16 years.

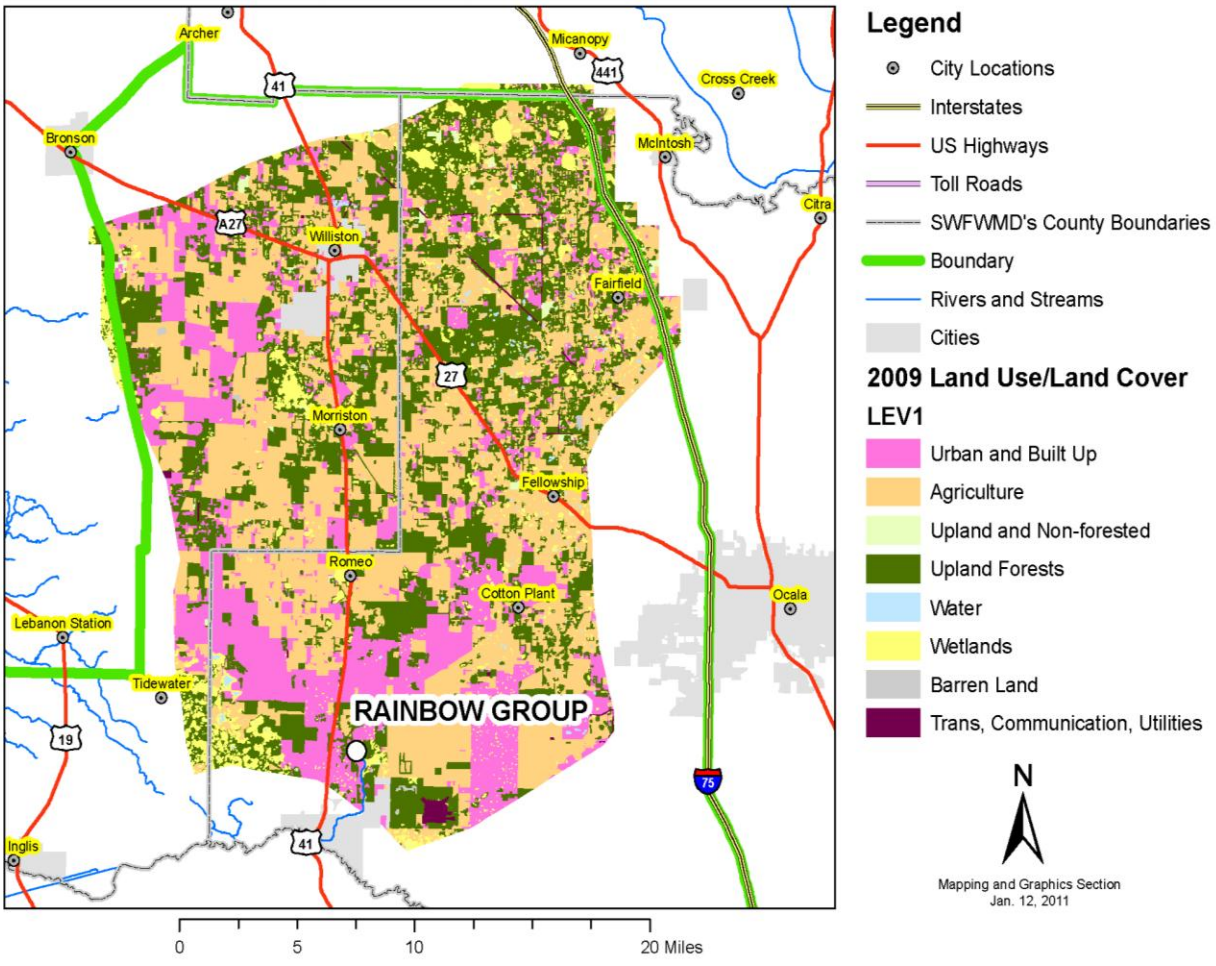


Figure 4-4. Land uses in the Rainbow Springs basin west of Interstate 75 (green line is the boundary of the SWFWMD).
Source: SWFWMD

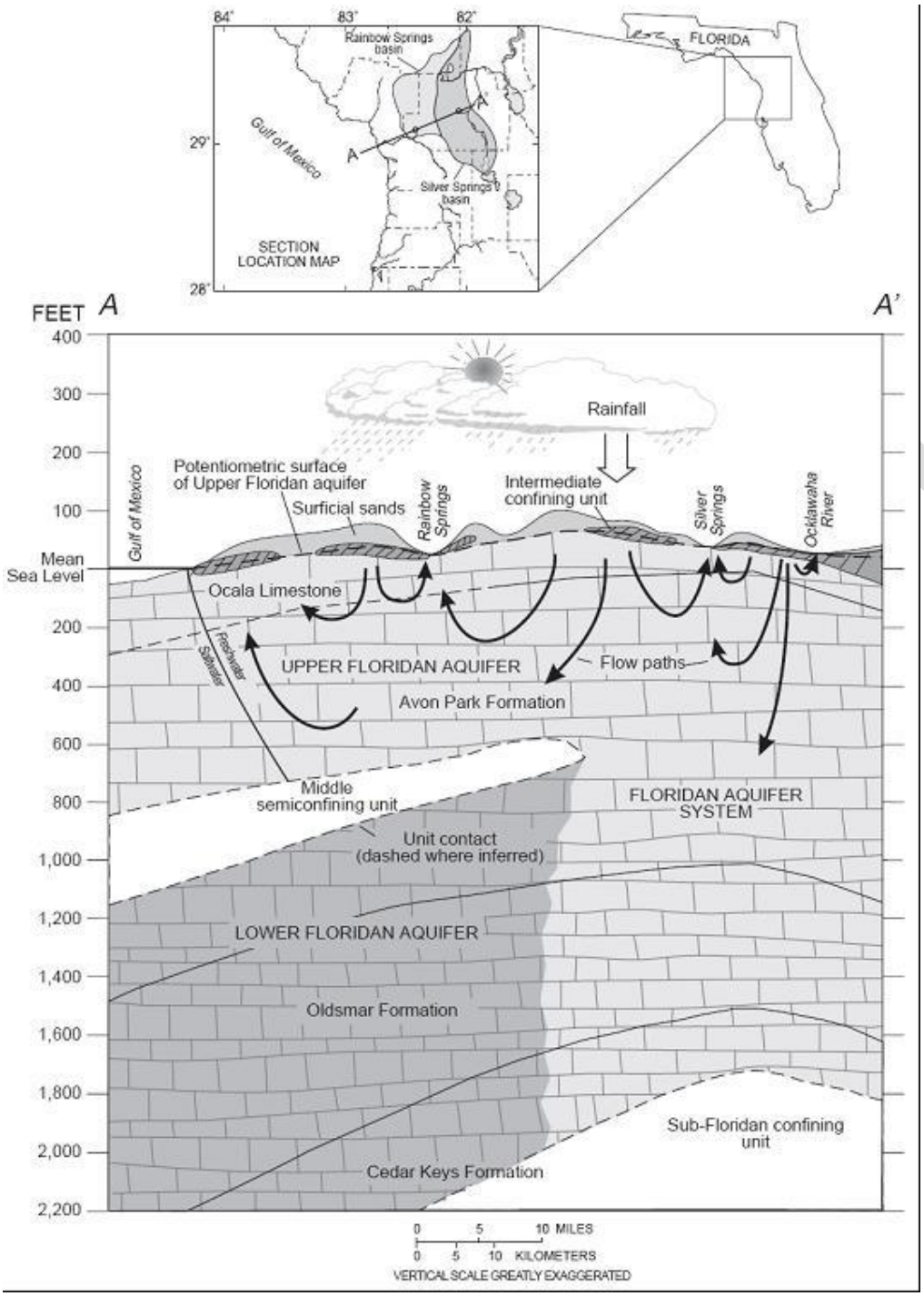


Figure 4-3. Generalized hydrologic section A to A' of the Floridan Aquifer in the Rainbow and Silver Springs basins.
Source: Knowles 1996

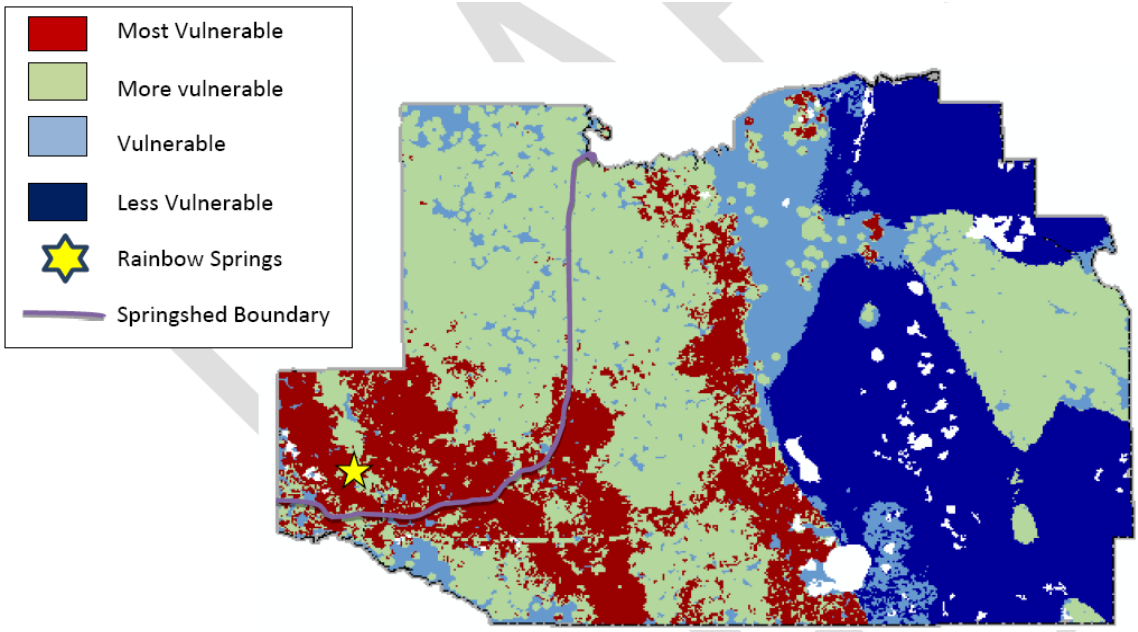


Figure 4-4. Marion County Aquifer Vulnerability Assessment (MCAVA).
Source: Baker and Cichon 2007

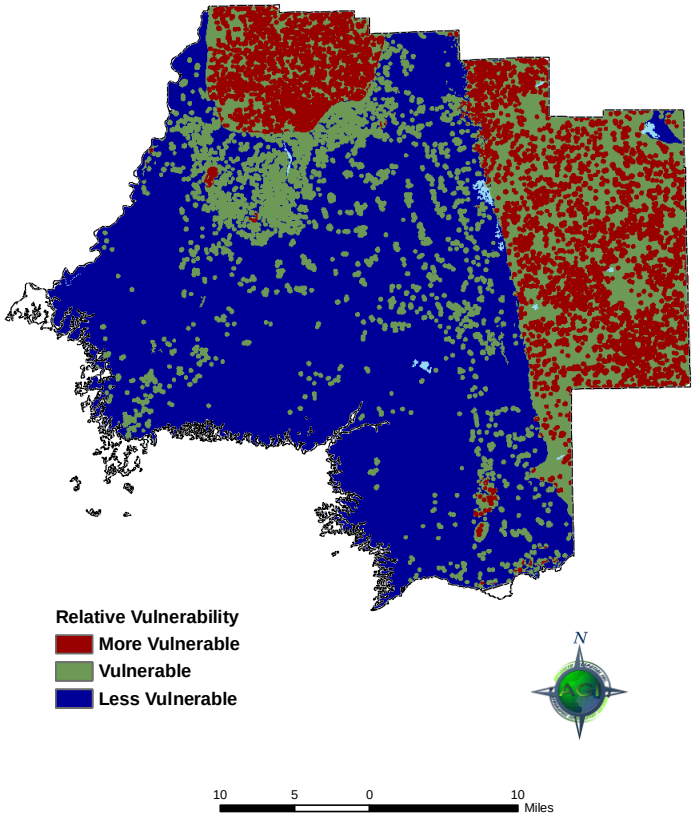


Figure 4-5. Levy County Aquifer Vulnerability Assessment (LCAVA).
Source: Baker et al 2009

4.2 Water Quality

4.2.1 Nitrate concentrations

Long-term records of spring water quality show that nitrate concentrations have increased exponentially in the Rainbow Springs Group from background concentrations of ≤ 0.1 mg/L in 1927 to concentrations of 2.1 mg/L in 2010 (**Figure 4-8**). Unlike phosphate, which sorbs onto metal oxides and carbonate minerals in calcitic soils and in the limestone matrix of the aquifer (Phelps 2004), nitrate is readily transported into aquifers making spring ecosystems particularly susceptible to land applications of nitrogen (Katz et al. 2009). Furthermore, the partitioning of nitrogen sources is difficult owing to the complexity of land use patterns (Vasques et al. 2010) and hydrologic flowpaths within the aquifer (Martin and Dean 2001).

A detailed study of nitrogen sources in the Rainbow Springs basin was conducted by Jones et al. (1996), who sampled 60 wells within the basin and multiple springs within the Rainbow Springs Group. They found that an extensive portion of the wells had nitrogen levels above what is considered the background concentration (<0.1 mg/L); 29% had concentrations between 1 and 5.2 mg/L, 54% had concentrations between 0.1 and 1.0 mg/L, and 17% had concentrations ≤ 0.1 mg/L. Nitrate concentrations were 1.0 mg/L for the largest springs in the Rainbow Springs Group. Interestingly, they found the highest nitrate concentrations west of Ocala, which coincides with the fracture zone trending northwest from the head springs discussed previously. High concentrations were also found along the fracture zone trending northeast from the head springs. The lowest concentrations were found in Fairfield Hills, in the north central portion of the basin, and they attribute this to the presence of Hawthorn clays overlying the aquifer that impede direct infiltration of water. The FDEP Springs Initiative Monitoring Network (begun in 2001) reported that of the 222 wells in the Rainbow spring basin with nitrate data, 41% had concentrations >1 mg/L and that the highest concentrations (>10 mg/L) were found in the central portions of the springshed (Harrington et al. 2010).

4.2.2 Nitrogen sources in the Rainbow Springs basin

Jones et al. (1996) identified 10 anthropogenic sources of nitrogen that contribute to groundwater-nitrate loading in the Rainbow Springs basin: septic tanks, residential turf fertilizer, golf courses, sewage effluent disposal, land disposal of sewage sludge, land disposal of septic sludge, row crops, cattle, horse farms and pasture fertilization with inorganic nitrogen. Fertilization of pastures, horse farms, and cattle farms were reported to be the three largest sources, with applications of 3,963 tons/year, 1,501 tons/year, and 1,256 tons/year, respectively. Nitrogen isotope values ($\delta^{15}N$) supported the finding that inorganic fertilizer was the principal source of nitrogen in the basin; 19 wells and five springs had $\delta^{15}N$ values between -0.5 and +4.6 ‰, which fall within the range for inorganic fertilizers (Jones et al. 1996). Albertin (2009) found $\delta^{15}N$ values of +3.9 to 4.2 ‰ in the waters of the Rainbow Springs Group, again, also within the range for inorganic fertilizers.

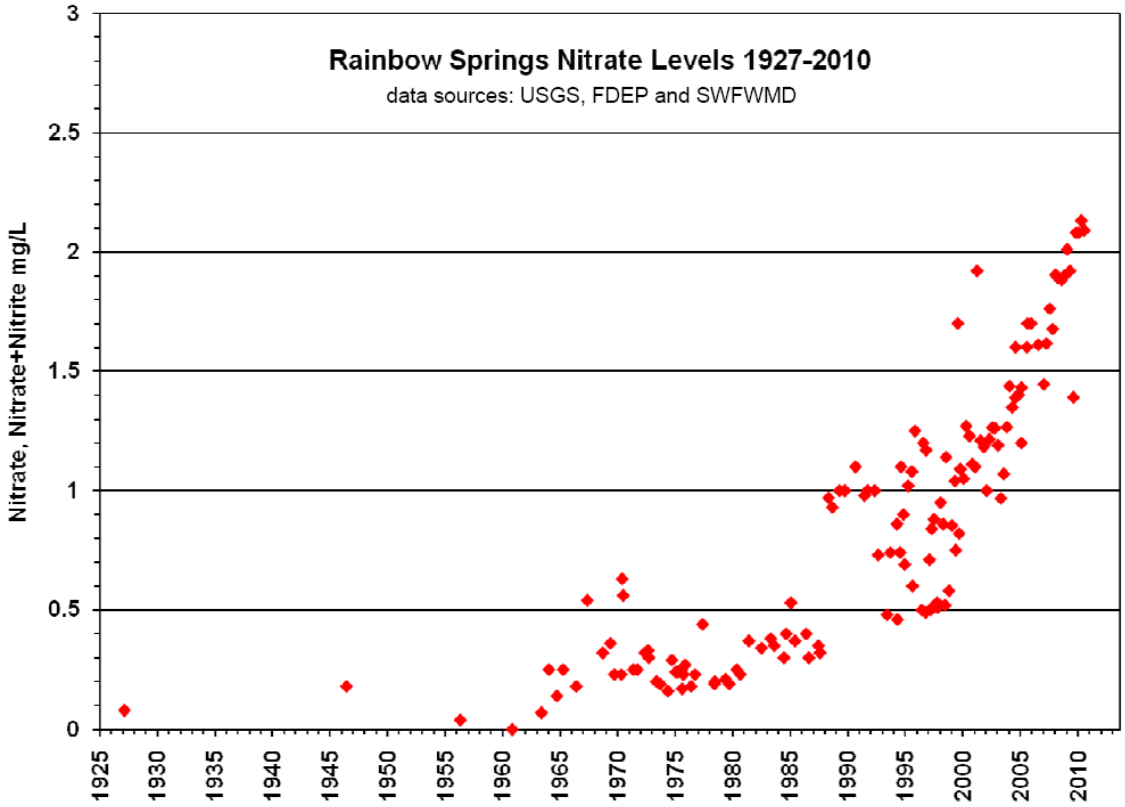


Figure 4-6. Mean annual Nitrate + Nitrite concentrations of the Rainbow Springs head springs area from 1927 to 2010 in mg/L.
Source: SWFWMD

4.2.3 Orthophosphate concentrations

As mentioned previously, phosphate readily sorbs onto metal oxides and carbonate minerals in calcitic soils and in the limestone matrix of the aquifer, and concentrations are relatively low within the Rainbow Springs Group. The median orthophosphate concentration from 2001 to 2006 was 0.029 mg/L at both Rainbow Spring #1 and #6, 0.034 mg/L at Rainbow #4, and 0.037 mg/L at Bubbling Spring (Harrington et al. 2010). Jones et al. (1996) measured total phosphorous in 60 wells throughout the Rainbow River basin and found values ranging from 0.023 to 0.764 mg/L. The highest values were found west and southwest of Ocala, and horse farms were indicated as probable sources.

4.2.4 Dissolved oxygen

Dissolved oxygen (DO) concentrations in the Rainbow Springs Group are some of the highest in the state. From 2001 to 2006, mean average DO was 6.58 mg/L at Rainbow #1, 5.74 mg/L at Rainbow #6, 5.17 mg/L at Rainbow #4, and 4.4.5 mg/L at Bubbling Springs (Harrington et al. 2010). The most accepted explanation for high DO at spring vents is that the water being released is mostly derived from the upper portion of the aquifer and is therefore comparatively "young" water whose residence time in the aquifer has been relatively short.

4.2.5 Water clarity

Water clarity, or transparency, in the Rainbow River decreases with increasing distance from the head springs area while chlorophyll *a* increased with increasing distance (Anastasiou 2006) (**Figure 4-9)**, and approximately 83% of the water clarity can be explained by chlorophyll *a* concentrations (SWFWMD 2008) (**Figure 4-10**). Since the water is so transparent, clarity was greatly affected by increases in chlorophyll *a*, but once chlorophyll *a* reached a concentration of 1.0 µg/L, the observed changes in clarity were much smaller. In a complementary study conducted by Cowell and Dawes (2005), phytoplankton was shown to be the source of chlorophyll *a*. Experiments conducted testing nutrient effects on phytoplankton indicated that up to 4-fold increases in either nitrate or phosphate had no significant effect on phytoplankton biovolume. However, biovolume increased when nitrate+trace metals were at elevated concentrations (Cowell and Dawes 2007) indicating a possible relationship between the two.

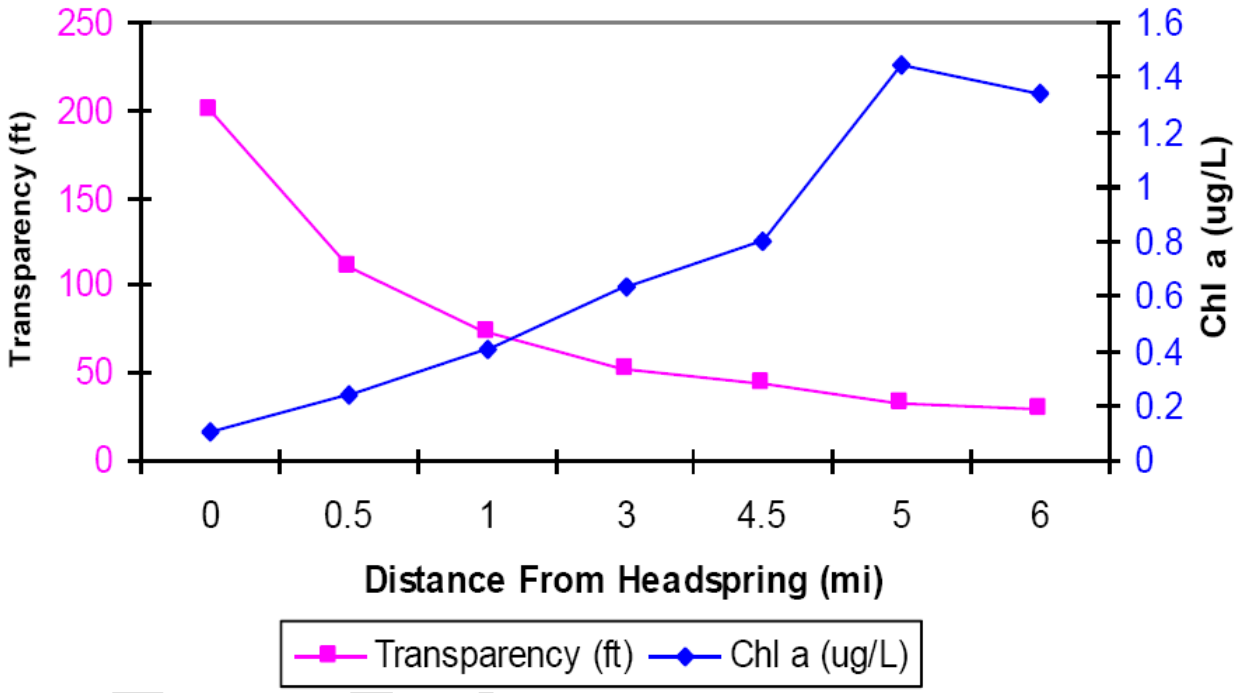


Figure 4-7. The change in water transparency and chlorophyll *a* concentration of the water along the Rainbow River with increasing distance from the head springs area.
Source: SWFWMD 2008

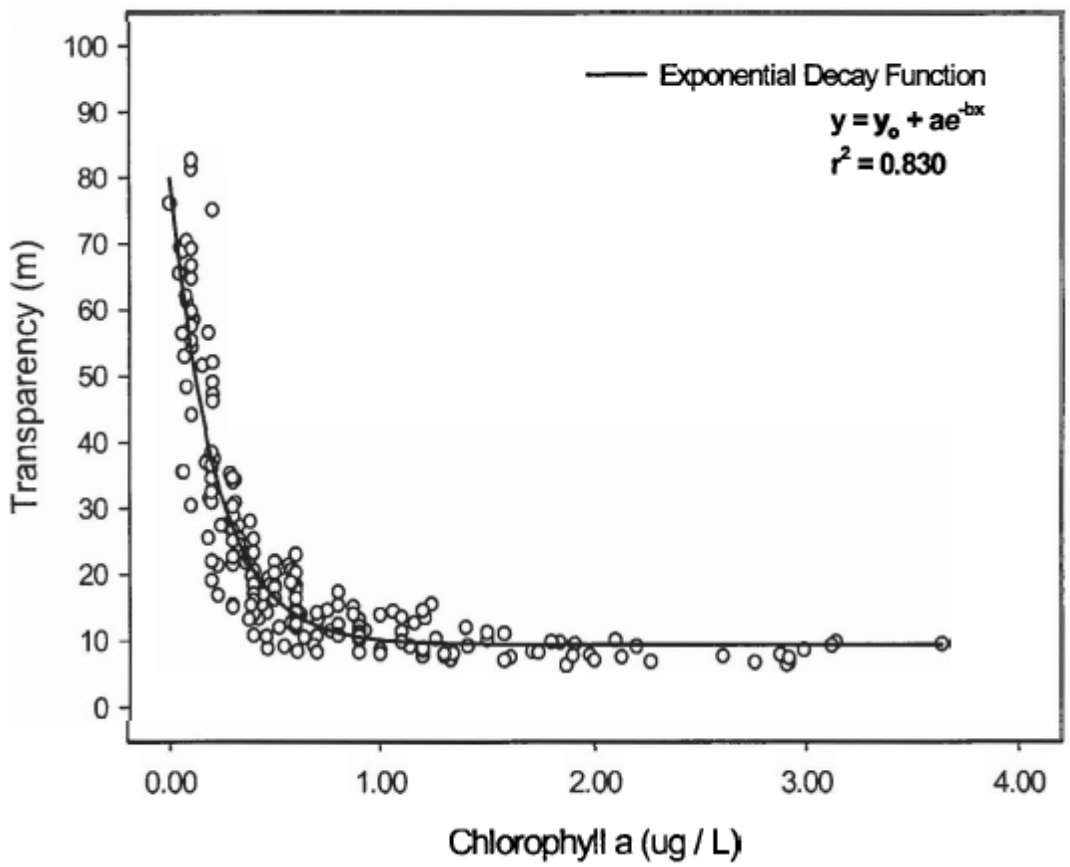


Figure 4-8. The relationship between water transparency and chlorophyll *a* concentrations in the Rainbow River.
Source: Anastasiou 2006

4.3 Springs Discharge

Groundwater discharge from the Rainbow Springs Group, the springs along Indian Creek, and the numerous vents along the length of the Rainbow River account for 97 to 99% of the river flow (Water and Air Research 1991), with 89% of the water discharging in the upper 1.5 miles of the Rainbow River (Jones et al. 1996). Long-term discharge measurements for the Rainbow River (**Figure 4-11**) indicate that flow has fluctuated between 480 and 1,230 cfs during the period 1931 to 2010. Discharge for the Rainbow River (U.S. Geological Survey Station # 02313100) is computed by USGS based on the relationship between discharge measurements taken ½ mile prior to the confluence with the Withlacoochee River and artesian pressure at Well # 290514082270701 near the head springs (Wetland Solutions, Inc. 2009). The downstream measurement is taken at the CR 484 bridge approximately 5 miles downstream from the head springs area. Rainbow River discharge varies seasonally. The mean monthly average discharge computed between 1965 to 2010 is at a minimum in June (652 cfs), which corresponds to the end of the dry season, and at a maximum in October (737 cfs), at the end of the wet season (from USGS Station # 02313100).

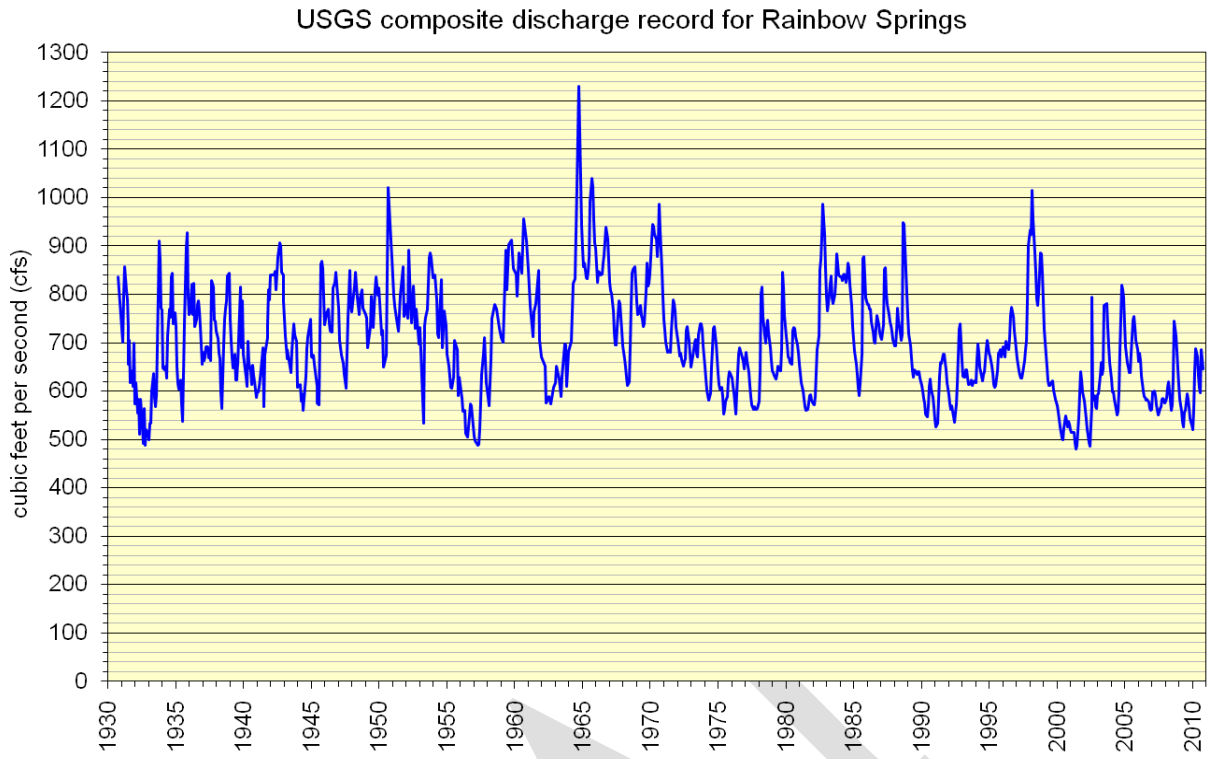


Figure 4-9. Composite discharge record for the Rainbow River from 1931 to 2010 (USGS Station #02313100).
Source: USGS

4.4 Biota

4.4.1 Submerged aquatic vegetation

The earliest published record of submerged aquatic vegetation (SAV) and benthic algae in the Rainbow River was provided by Odum (1957), who characterized the river as being comprised of *Sagittaria kurziana* beds in the upper reaches and then shifting largely to the alga *Chara* sp. as turbidity increased downstream. Systematic monitoring of the SAV in the Rainbow River by PBS&J working on a contract for the SWFWMD began in 1991 and has occurred every five years since then (1996, 2001, and 2005)(PBS&J 2007). A new study, scheduled to be completed by 2012, is in progress at the time of this writing and is being conducted by Atkins, North America. This work satisfies the requirements of the river being designated as a SWIM (Surface Water Improvement and Management) priority water body in 1989. Analyses of this monitoring effort between 1996 and 2005 showed that *Sagittaria kurziana* (a native species) and *Hydrilla verticillata* (an invasive exotic species) were by far the dominant species along the Rainbow River (**Table 4-1**) (PBS&J 2007). *Hydrilla verticillata*, *Vallisneria americana*, and *Najas guadalupensis* had the greatest change in percent cover between 1996 and 2005, with increases of 2.6%, 1.6% and 1.6%, respectively.

Additionally, PBS&J (2007) found that in 2005, Odum's original characterization still held true. *Lyngbya wollei* and *Vaucheria* sp. were identified as the most common mat-forming benthic

algal species along the Rainbow River (Albertin 2009). *Lyngbya* was found in Rainbow Springs as early as 1939 (from a collection at the Farlow Herbarium, Harvard University) (Pinowska et al. 2007).

Table 4-1. Percent Cover and Changes in Percent Cover of Submerged Vegetation and Bare Substrate in the Rainbow River from 1996 to 2005
Source: PBS&J 2007

SUBMERGED VEGETATION	1996 Percent Cover	2000 Percent Cover	2005 Percent Cover	96-'00 Change in % Cover	00-'05 Change in % Cover	96-'05 Change in % Cover
Ceratophyllum demersum	1.9%	1.1%	2.0%	-0.8%	0.9%	0.1%
Chara sp.	1.0%	1.5%	0.7%	0.5%	-0.8%	-0.3%
Hydrilla verticillata	16.2%	17.5%	18.8%	1.3%	1.3%	2.6%
Ludwigia repens	0.04%	0.05%	0.18%	0.01%	0.14%	0.14%
Myriophyllum sp.	0.01%	0.01%	0.01%	0.01%	-0.01%	0.00%
Najas quadalupensis	1.8%	0.7%	3.4%	-1.1%	2.7%	1.6%
Nasturtium sp.	0.002%	0%	0.01%	-0.002%	0%	0.00%
Potamogeton illinoensis	0.4%	0.5%	0.5%	0.1%	0.0%	0.1%
Sagittaria kurziana	35.7%	34.9%	35.4%	-0.8%	0.5%	-0.3%
Utricularia sp.	0.7%	0.1%	0.9%	-0.6%	0.8%	0.2%
Vallisneria americana	4.3%	4.1%	5.9%	-0.2%	1.8%	1.6%
Total bare substrate	7.6%	11.3%	4.7%	3.7%	-6.6%	-2.9%

4.4.2 Fauna

A complete list of aquatic and terrestrial wildlife in the Rainbow River watershed can be found in Florida Game and Fresh Water Fish Commission (1992) (now the Florida Fish and Wildlife Conservation Commission (FWC), report prepared for the SWFWMD 1995 SWIM Plan. Species found in the Rainbow River and classified by the FWC as being of special concern include the American alligator (*Alligator mississipiensis*), the limpkin (*Aramus guarauna*), the little blue heron (*Egretta caelulea*), the snowy egret (*Egretta thula*) and the tricolor heron (*Egretta tricolor*). Federally endangered species include the bald eagle (*Haliaeetus leucocephalus*) (considered threatened by the FWC) and the wood stork (*Mycteria americana*) (also considered endangered by the FWC).

NOTE: Biologists from FDEP have done assessments of the benthic community and macro-invertebrates in the headspring area of the Rainbow River. This data was not gathered by the authors during this project.

4.4.3 Changes in turtle populations in the Rainbow River

Eight species of aquatic turtles are found in the Rainbow River: the loggerhead musk turtle (*Sternotherus minor*), the eastern river cooter (*Pseudonemys concinna*), the Florida cooter (*Pseudonemys floridana*), the common musk turtle (*Sternotherus odora*), the Florida red-bellied cooter (*Pseudonemys nelsonii*), the Florida softshell turtle (*Apalone ferox*), the striped mud turtle (*Kinosternon barii*), and the chicken turtle (*Deirochelys reticularia*) (Heustis and Meylan 2004).

Heustis and Meylan (2004) found that the structure of the turtle community in the Rainbow River had changed since initial surveys were conducted by Marchand (1942). One of the major changes was the growth in the population of *S. minor*, which became the largest component of the turtle population (**Figure 4-12**). The second was the decrease in relative abundance and average size of the *Pseudonemys* species since the 1940s. Possible reasons given for this decrease include a lack of suitable basking sites and collisions with boats.

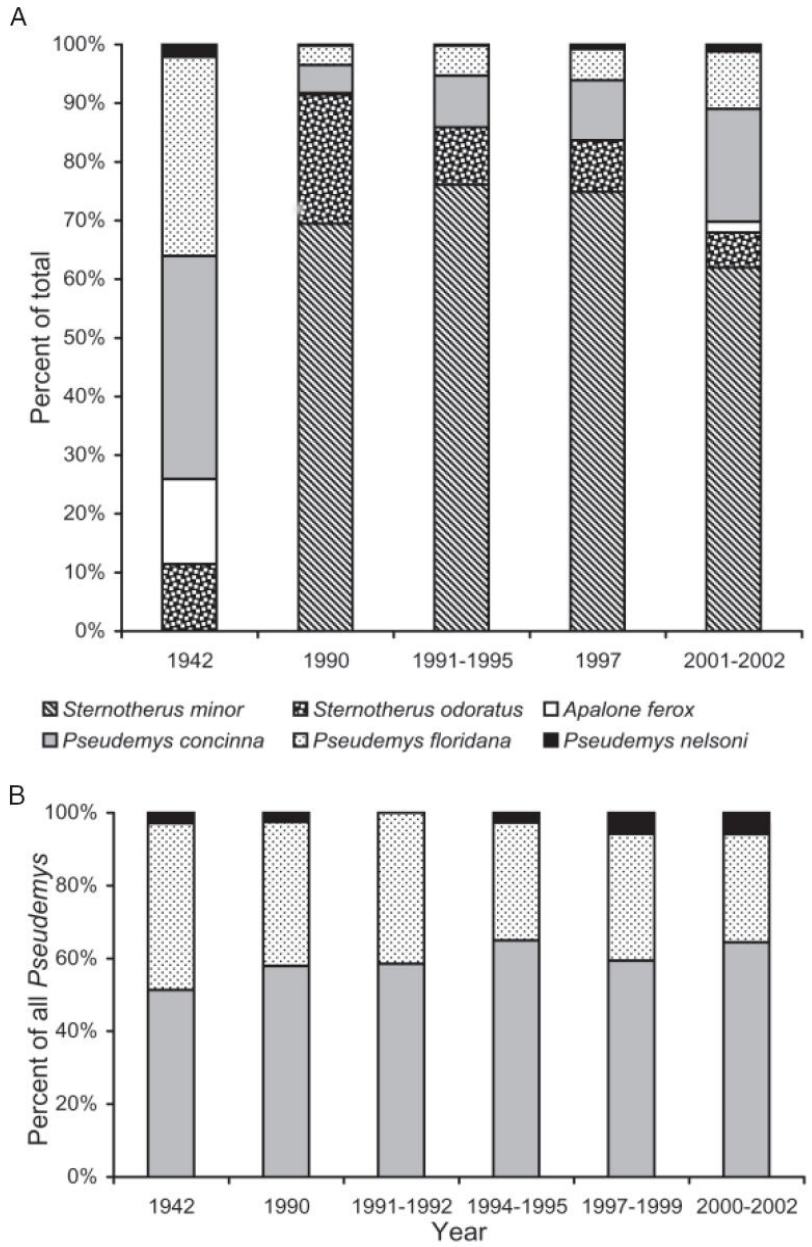


Figure 4-10. Community structure of the turtles in the Rainbow River as relative abundances of all turtles (A), and relative abundance of only *Pseudemys* species.
Source: Heustis and Meylan 2004

4.4.4 Mussels and fish in the Rainbow River

Surveys of the mussel and fish populations were conducted by Walsh and Williams (2003). Only native mussel species were found, *Elliptio* sp. and the Florida pondhorn (*Uniomerus carolinians*). Mussels were less common in the upper reaches of the river near the head springs area than in the lower reaches, even in areas that provided suitable habitat (tree roots, submerged logs, mixed substrate of sand and detritus). Walsh and Williams (2003) found 20 species of fish from 16 genera and 10 families, with the most common species by far being the eastern mosquitofish (*Gambusia holbrooki*) (29% of samples collected).

5 Economic Value

The Rainbow Springs and River provide significant economic value to southwestern Marion County. That value is directly dependent upon the physical and biological health of the system. Visitors come to the springs and river for a variety of reasons: sightseeing, swimming, boating, diving, fishing, and tubing. There are also several festivals held both in Dunnellon and in Rainbow Springs State Park (RSSP) that attract large crowds. There has been considerable real estate development over the last three decades in the area around the spring and along the river. Most new developments are part of the Villages of Rainbow Springs Property Owners Association. Billboards in the area advertise these developments with images of people recreating on the river, and most of the developments have the word "Rainbow" in their name. It seems clear that Rainbow Springs and River are integral to the economic value of residential properties and businesses in the area. If the springs and river became severely impacted by declining flows, poor water quality, recreation beyond its capacity to sustain, or some combination of these factors, the impact on the local economy would likely be severe.

There have been some studies to determine the economic value of certain natural resources in the state of Florida. The Florida State Parks Economic Assessment for 2009-10, released in September 2010, revealed a $950 million impact on local economies that are in close proximity to Florida State Parks. Additionally, $66 million was generated in sales taxes to the state of Florida, and 18,900 jobs were supported by this economic activity. The share of this value contributed by RSSP in 2009-10 was $8.4 million providing $587,954 in state sales taxes and supporting 168 jobs.

Florida State University studied the economic impacts of Ichetucknee, Volusia Blue, Wakulla, and Homosassa Springs in 2003 (**Table 5-1**). This study (Bonn and Bell, 2003) measured spending on lodging, restaurants, groceries, transportation, shopping, entertainment, and admissions fees to parks. It used a formula that assumed additional expenditures by visitors beyond the studies done by the Florida Park Service. The study noted that Volusia Blue was the only park to have a decrease in attendance over a ten year period (1992-2002) despite being close to Orlando and Daytona Beach. This appeared to be related to environmental degradation suggesting that the quality of the springs affected the attendance and thus the economic impact.

Table 5-1. Data from Bonn and Bell (2003) of the Economic Impact of Four Springs

Spring	Economic Impact	Wages & Salaries	Jobs	Number of Visitors	Non-Resident Visitors
Ichetucknee	$22.7 million	$5.09 million	311	188,845	90%
Wakulla	$22.2 million	$4.33 million	347	180,793	70%
Homosassa	$13.6 million	$3.13 million	206	265,977	64%
Volusia Blue	$10.0 million	$2.38 million	174	337,356	65%
Average	**$17.13 million**	**$3.73 million**	**259.5**	**243,243**	**70.48%**

A second study by Bonn in 2004 for the SJRWMD included profiles of eight springs: Silver Glen, Silver, Alexander, Apopka, Bugg, Ponce de Leon, Gemini, and Green Springs. The annual economic impact as well as employment and wages created for each of these springs was estimated. Silver Springs led the other springs with 1 million visitors annually who expended $248 per party creating an annual economic impact of $61.45 million with $12.61 million in wages and 1,060.5 full/part time jobs being directly related to the springs. More than 70% of the visitors came from outside of Marion County.

Hazen and Sawyer (2008) estimated the total value provided to Volusia, Brevard, Stuart, St. Lucie, and Indian River counties by the Indian River Lagoon. The total impact calculated was $3.725 billion. The estimate included annual recreational expenditures of $1.302 billion, real estate values directly related to the proximity of the lagoon of $934 million annually, $629.7 million worth of income for jobs directly related to restoration of the lagoon, $91 million worth of expenditures for research and education, and $3.8 million in the dockside value of commercial fishing products. In addition to these "revealed preferences," there were additional "stated preferences" for a recreational use value of $762 million and a nonuse value of $3.4 million. The real estate value represents almost 22% of the total value of property in the area. The study predicted that the stated preferences would increase with an increase in the amount and diversity of wildlife in the lagoon which demonstrates a direct correlation between willingness to pay and the quality of the local environment as a contributor to quality of life.

A study conducted at Jackson Blue Spring in Jackson County (Aston and Huth 2011) estimated the economic benefits of cave diving. It found that at this spring $575,000 was spent annually by cave divers at a rate of $1,075 per person per year. Divers were also asked how their spending would change if access was improved and if a privately owned spring was opened for diving. Divers stated they would spend an additional $150 per person per year or about $82,000 total in new expenditures per year. It should be noted that there are no known divable caves at Rainbow Springs.

Shrestha et al. (2002) conducted a survey in the Ocala National Forest in 1999 and asked visitors questions regarding the current state of facilities, recreation opportunities, food and supplies, rentals, interpretive activities, and overnight accommodations and their willingness to pay additional expenses for improvements to park facilities. The survey estimated that visitors were willing to pay $1 million for basic facilities, $1.9 million for moderate improvements, and $2.5 million for high quality improvements.

Recommendation

A comprehensive study of the economic contribution of Rainbow Springs and River to southwestern Marion County should be conducted using a similar methodology to the Hazen and Sawyer study described above. This study should be done together with a similar analysis of the value of Silver Springs and River. There is often considerable controversy about expenditures needed for proposed environmental improvements e.g., expenses needed to upgrade septic systems or to change farm practices over to best management practices (BMPs). A clear understanding of the economic value that Rainbow Springs and River create would provide an estimate of the cost of inaction, if that inaction leads to the demise of the quality of the resource and therefore the loss of the economic contribution.

6 Existing Legal Protections

Rainbow Springs and River are protected by a variety of federal, state and local statutes and ordinances. These are summarized in **Tables 6-1**, **6-2**, and **6-3** below.

Table 6-1. Federal Laws and Policies that Apply to the Rainbow Springs and River and Rainbow Springs Basin

Federal Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit or Approval
Rivers and Harbors Act, 1899 Sections 9 and 10	USACE	Water and Wetlands	Prohibits unauthorized construction in or over navigable waters of the U. S.	Yes
Clean Water Act, 1972 Amended 1977 Section 404 (33 CRF Parts 320-330) NPDES Permit Wastewater Stormwater (40CFR Parts 122,123,124)	USACE	Water and Wetlands	Controls discharge of dredged or fill material into waters of the US Permit requirements for wastewater treatment plants Directs States to develop Total Maximum Daily Loads(TMDLs)	Yes USACE EPA
Fish and Wildlife Coordination Act of 1956	USACE	Water and Wetlands	Requires USACE to coordinate permit applications with state and federal fish and wildlife agencies	No
Archaeological and Historical Preservation and Protections Acts, 1974 PL 74-292; 16 U. S. C. 461*et seq* PL 93-291; 16 U. S. C. 469 PL 89-665; 16 U. S. C. 470 PL 96-95 ; 16 U. S. C. 470aa-11	Dept. of Interior	Archeological and Historic	Establishes policy, programs, rules, and regulations regarding the preservation and protection of archeological and historic resources. Establishes civil and criminal penalties for unlawful excavation and removal.	Yes for excavation and removal
Endangered Species Act of 1973 PL93-205; 16 U. S. C. 1531 *et seq*	FWS/ NMFS	Species & Habitat	Protects all marine and non-marine endangered and threatened species and the critical habitat on which they depend.	Yes
Executive Order of 1979, Creation of Federal Emergency Management Agency	FEMA	Flood Plain	Provides flood insurance and provides guidance on building codes and floodplain management	No
National Environmental Protection/Policy Act (NEPA), 1970 PL 91-190; 42 U. S. C. 4321-4370d	CEQ	Land and Water	Requires federal agencies to prepare reports including an Environmental Impact Statement (EIS) for all 'major federal actions significantly affecting the quality of the human environment. An Environmental Assessment (EA) may be performed first with recommendations for either Findings of No Significant Impact (FONSI) or that an EIS is necessary.	Yes
Soil Conservation Act (16 U.S.C. 590a)	NRCS	Land and Water	Directs NRCS to prevent soil erosion through local regulations and watershed improvement projects	

Table 6-2. State of Florida and Regional Agencies Laws and Policies that Apply to the Rainbow Springs and River and Rainbow Springs Basin

State of Florida Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval Agency
Florida Aquatic Preserves Act, 1975 F.S. Part II Chapter 258, F.A.C. 18-20	FDEP	Water	Sets the intent of the establishment of the state's aquatic preserve system and sets guidelines for administration and management of the preserves. Addresses the need to manage cumulative impacts within and surrounding the preserve, protection of indigenous life forms from sale or commercial use and the need for resource inventories and management plans for each preserve.	FDEP
Outstanding Florida Water (OFW) F.S. , 1979 Rainbow designation 1994 (62-302.700 F.A.C.). (Rule 17-302.700(9), F.A.C.)	ERC & FDEP	Water	Prohibits direct and indirect pollutant discharges that would lower the existing water quality. Permits for dredging and filling have to be in the public's interest. Establishes a process for designating Outstanding Florida Waters (OFW) worthy of special protection with more protective standards.	FDEP or SJRWMD
Warren S. Henderson Wetlands Protection Act, 1984 (403. 92-. 938,FS)	FDEP & WMD	Water and Wetlands	Regulates activities in wetlands considered to be waters of the state. Note – Florida and USACE have permitting jurisdiction; Florida's rules require a hydraulic connection to surface water, USACE does not.	FDEP or WMD
Management and Storage of Surface Waters, (Ch. 40C-4, Ch. 40C-40, and Ch. 40C-41, F. A. C. , Sec 403, FS)	WMD	Water and Wetlands	Establishes standards and permit requirements for the management, consumptive use, and storage of surface waters including storm waters and impoundments.	WMD
Surface Water Quality Standards (Rule 17-302. 400, F. A. C.)	FDEP	Water	Establishes surface water classifications for specific uses and corresponding water quality standards.	FDEP
Local Government Comprehensive Planning and Land Development Act, 1985 (Ch. 163.3161-163.3243, F. S. ; Ch. 9J-6, 9J-24, F. A. C.	FDCA	All	Directs local governments to adopt comprehensive plans and land development regulations; outlines rules and minimum criteria; and outlines elements to be included in plans. Ch. 380, F. S. establishes criteria for Developments of Regional Impact (DRI).	FDCA, RPCs, Local Government
Environmental Resource Permits Chapter 40C-41, F.A.C	WMD	All	Lays down guidelines for permit requirements in surface water management.	WMD, Local Government
RPC Policy Goal 4.10 & 4.11 July 1998	EC Florida RPC	Water Resources	Best management practices (BMPs) will be practiced for control of erosion and sedimentation. The hydrological and ecological functioning of the region's river systems is protected.	DCA, RPCs, Local Government
RPC Policy	EC	Wetlands	Ensuring protection of rare or endangered ecosystems (identified in state, regional or	DCA, RPCs,

Table 6-2. State of Florida and Regional Agencies Laws and Policies that Apply to the Rainbow Springs and River and Rainbow Springs Basin

State of Florida Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval Agency
Goal 4.24 July 1998	Florida RPC		local lists & inventories).	Local Government
RPC Policy Goal 4.29 &.30 July 1998	EC Florida RPC	Habitat	Establishment of buffer zones encouraged to protect water quality and quantity and to provide habitat for semi-aquatic or water dependent terrestrial wildlife. Recommendation of locating these buffer zones landward of regionally existing wetlands. It states that natural vegetative communities (native plants and animals) shall be conserved and protected to ensure their existence in the future (encouraged through comp. plans for local areas to establish adequate conservation areas, open spaces, river buffers, etc.).	DCA, RPCs, Local Government
Impaired Waters Rule (Ch. 62-303)	FDEP	Water	Established a methodology for identifying Impaired Florida Waters and the calculation of TMDLs for those bodies of water.	
Springs Protection Act, July 2006	Florida Senate		Provides for the creation of the Florida Springs Commission, whose duty is to identify strategies that will protect, restore, and preserve Florida's springs. Lays out minimum requirements for assessment information and model plans for the springs.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Marion County Board of County Commissioners- Land Development Code, Amendment 14, Section 6.4- Springs Protection Ordinance	Marion Co.	All	The objective of the Springs Protection Ordinance is: "to preserve the quantity and protect the quality of the Floridan Aquifer underlying all of Marion County and to protect the environmental, recreational, and economic values of Silver Springs and Rainbow Springs in the interest of public health, safety and general welfare. This is to be accomplished by regulating land uses and activities which can adversely impact the quality and quantity of groundwater within the identified Springs Protection Zones (SPZ)." **Sec 6.4.4** Establishes boundaries for the primary and secondary SPZ. **Sec 6.4.5.A** Lists prohibited activities within the Primary SPZ **Sec 6.4.5.B** Lists permitted uses with conditions, including design requirements set forth for "New and expanding golf courses," "New and existing auto salvage yards within the Secondary SPZ," "New and expanding uses which store and/or stock fertilizers, pesticides, and pool and spa chemicals," "Hazardous Materials and Waste Facilities," "Construction and Demolition Debris (C&DD) Disposal Facilities,"	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Section 8.2.10 Landscape Standards and Tree Preservation			"Mining Operations," and "Heavy Industrial and Commercial Uses" **Sec 6.4.5.C** Provides detailed restrictions on agricultural uses within the SPZ, including the prohibition of Concentrated Animal Feeding Operations, restrictions on manure handling within the SPZ, required use of fertilizer BMPs, and so forth. **Sec 6.4.6.B** Provides design standards for general purposes, very detailed standards (7 pages worth) for "domestic wastewater management," and detailed standards (2-3 pages) for "water supply management," "natural groundwater recharge protection," "stormwater runoff management," and "karst feature protection." **Sec's 8.2.10.d-i** Require permitting for certain tree removals, set minimum standards for tree replacement requirements (and maintenance standards for those replacement trees), require protection for trees not cleared for removal during development, and lay down regulations for inspections and enforcement of adhering to these standards **Sec 8.2.10.k** Provides regulations concerning the maintenance of native vegetation, landscaping with native vegetation, and regulations on the minimum amount of land that must be landscaped in non-residential, new residential, or mixed use development. It also provides guidelines for buffering practices, irrigation design standards, and other protections. **Sec 8.2.10.i** Sets limitations on amount of coverage allowable for high and low volume irrigation.	
Marion County Code of Ordinances Ch. 3, Alcoholic Beverages Ch. 5, Boats, Docks and Waterways: Article IV. Ch. 5.5, Building and Building Regulations Ch. 16, Solid Wastes	Marion Co.	Water, habitat Water, habitat Water, habitat Water Water	**Sec 3.8** prohibits alcoholic beverages on the Rainbow River. **Sec 5.52** disallows any disposable containers for food or beverage on Rainbow River **Sec 5.53** prevents the use of any motorcraft in a designated Environmentally Sensitive Area **Sec 5.54** states that a no wake-idle speed only zone is established on the entire Rainbow River, unless an area is a designated Environmentally Sensitive Area, which is governed by section 5.53. Provides regulations for building/ construction **Sec 5.5-33** lays down guidelines for permitting, including stormwater drainage regulations Provides regulations for solid waste management	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Ch. 17, Special Assessments: Article IV.		Water	**Sec 17-111** establishes a stormwater management program **Sec 17-112** establishes a stormwater management services fund. Services and facilities for stormwater management will be provided through stormwater assessments	
Ch. 19, Water and Sewers: Article II.		Water	**Objectives:** "To prevent the introduction of pollutants into the publicly owned treatment works that will interfere with its operations; To prevent the pass through of pollutants into the publicly owned treatment works and subsequently into receiving waters; To protect both personnel who may be affected by wastewater and sludge in the course of their employment, and the general public; To promote reuse and recycling of industrial wastewater and sludge; To provide for fees for the equitable distribution of the cost of operation, maintenance, and improvement of the publicly owned treatment works; and To enable the county to comply with its national pollutant discharge elimination system permit conditions, sludge use and disposal requirements and any other federal or state laws to which the publicly owned treatment works is subject."	
Article IV.		Water	**Objectives:** "to implement procedures that promote water conservation through the more efficient use of landscape irrigation." **Sec 19-223** Sets a schedule for when irrigation is allowed. Exceptions to this schedule are provided in section 19-224	
Article V.		Water	**Objectives:** "This article regulates the proper use of fertilizers by any applicator; requires proper training of commercial and institutional fertilizer applicators; establishes training and licensing requirements; specifies allowable fertilizer application rates and methods, fertilizer-free zones, low maintenance zones, and exemptions. This article requires the use of best management practices which provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers."	
Marion County Land Development Code: Article 5, Zoning	Marion Co.		**Sec 5.3** provides zoning classifications for the unincorporated area of Marion County, helping regulate the flowing: "the location, height, bulk and size of buildings and other structures; the percentage of the lot, tract, or parcel which may be occupied; the size of lots, tracts or parcels, courts and green spaces; the density and distribution of population; the location and uses of land, buildings and structures for trade, industry, residential, recreation, public activities or other purposes."	
Article 6, Overlay Zones		All	**Sec 6.2** establishes Environmentally Sensitive Overlay Zones (ESOZ) to protect native habitats, vegetation, wetlands, and other sensitive areas. It lays out regulations	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Article 12, Wellhead Protection		Water	that developers must abide by. **Sec. 12.4** establishes Wellfield Protection Areas to protect potable water quality. **Sec. 12.7** defines hazardous substances or materials	
Marion County Comprehensive Plan	Marion Co.	Water	**Sec. 1.11** Requires the existence of a buffer zone around new development when adjacent to existing incompatible land uses **Sec. 1.22** Land Development Regulations will contain standards protecting springs and springsheds. Some restricted/prohibited practices are listed. **Sec. 4.2** Listing of developmental design standards designed to protect recharge/ springs areas. Addresses impervious surface coverage, stormwater collection, hazardous materials, and so forth. **Sec. 4.5c** "Resource extraction which will exacerbate or result in an adverse effect on springs and environmentally sensitive areas which cannot be restored shall be prohibited." **Sec. 4.5d** Springs and other environmentally sensitive areas will be protected from mining activities in surrounding areas and by buffer zones surrounding them. **Sec. 4.9j** "Establish a Springs Protection Zone (SPZ), that includes the Primary and Secondary Zone, that are additional, but distinct parts of the ESOZ." **Sec. 13.0** Discusses implementation of a Transfer of Development Rights program designed to protect natural resources including springs/high recharge areas.	
Code of Ordinances (Ord. No. 2008-12, § 1, 1-12-2009)	City of Dunnellon		**Sec. 97** Promotes environmentally sensitive and efficient uses of agricultural land, lists functions of the conservation subdivision of the code of ordinances (chapter 97).	
Comprehensive Plan, Conservation Element, Objective 2: Natural Resource Protection Objective 3: Soils, Minerals and Native Vegetative Communities	Levy Co.	Water	**Policy 2.9** States that advanced secondary treatment systems may be required in ESLs, when determined necessary by the Board of County Commissioners. Septic tanks/ drainfields located to protect Natural Reservation areas and lands managed by government or nonprofit agencies for conservation from the discharge of improperly treated effluent. **Policy 3.2** States that a Land Use and Natural Resource Map series will show karst features and springs and will be utilized in analyzing future development proposals. **Policy 3.8** States that ESLs will be protected from mining operations **Policy 3.10** States that "The County will develop performance standards that will permit the monitoring and early detection of water contamination or excessive run-off into adjacent areas resulting from mining, agricultural or construction excavations" **Policy 3.12** Encourages "the use of rejuvenation practices for managed forested lands to reduce or eliminate excessive water run-off or water contamination problems"	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Objective 4: Forestry/ Wildlife Habitat Conservation Objective 6: Protect the Quality and Quantity of Current and Projected Water Sources			**Policy 4.5** States that native vegetation and agricultural/forestry lands will be maximally preserved through providing open space, lot coverage, and developmental requirements. **Policy 6.1** States that any known activities that are damaging to the quality or quantity of water sources will be banned through local rules/ordinances. **Policy 6.2** States that the county, SRWMD, and SWFWMD will coordinate a plan for growth/development that protects the hydrology of the area **Policy 6.3** Protects potable water sources from contamination via standards in Land Development Regulations for potable wells, cones of influence and water recharge areas. **Policy 6.4** Groundwater recharge areas, surface water and wellfield protection areas will be protected from inadequate stormwater management and inappropriate use of septic tanks. Intense or inappropriate development will also be forbidden in karst sensitive areas and in designated environmentally sensitive land. **Policy 6.5** Large groundwater withdrawals with potentially adverse side effects will be evaluated before they are permitted. **Policy 6.6** Lays out strategies to prevent water from being exported out of the county. **Policy 6.7** Water withdrawals exceeding 100,000 g.p.d. will be reviewed before they are approved. **Policy 6.8** Lays down wellfield protection details and uses allowable within both primary and secondary wellhead protection zones. **Policy 6.9** Requires soil tests for proposed developments prior to approval for the implementation of septic tanks, sewer treatment plants, or solid waste disposal sites. **Policy 6.12** states that emergency conservation measures will be implemented when requested by SRWMD and SWFWMD, and an emergency water conservation plan may be developed when deemed necessary. **Policy 6.13** Aquifer recharge areas will be protected from developmental impacts;	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Objective 9: Hazardous Waste			proposed development sites will be encouraged to retain soils and vegetative coverage. **Policy 6.14** Incentives (such as density bonuses) will aid in providing innovative design and construction materials that retain soil permeability. **Policy 6.15** "reservation of open space lands shall be encouraged in areas of high natural recharge, wetlands areas, and in areas identified as Environmentally Sensitive Land." **Policy 9.2** States that natural resources will be protected from hazardous wastes.	
Comprehensive Plan, Future Land Use Element, Policy 1.2	Levy Co.		**Conservation Element** section a. provides restrictions on septic tanks given certain residential densities (for example, in 10-year flood areas with no central services and a residential density of 1 dwelling per 20 acres, septic tanks are prohibited).	
Unified Land Development Code	Alachua Co.		**Sec. 406.41** states that no alteration shall occur in, on or over a surface water (includes springs), wetland, or buffer area, and that no alteration shall occur adjacent to a connected surface water that changes the water regime in a way that prevents hydroperiod or function maintenance. **Sec. 406.43** sets guidelines for water resource buffers, including minimum and average buffer distances for different protected water resources. **Article 8**, entitled "Springs" is currently reserved and unavailable as it is being rewritten (accurate as of 2/7/2011) **Sec. 406.58** defines high aquifer recharge areas, and section **406.59** lays down standards and restrictions that apply to both stormwater and hazardous materials. **Sec. 406.61** provides a delineation of wellfield protection zones and section **406.62** lays out restrictions for each classification of protection zone. **Sec. 406.70** states that all new wastewater treatment plants in high aquifer recharge areas or in semiconfined or unconfined areas must provide advanced treatment that includes nutrient removal prior to discharge. Existing plants in high aquifer recharge areas must be upgraded to these same standards. Also provides regulations on surface water/ wetland discharge, deep well injection processes, spray irrigation, the	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
Unified Land Development Code	Alachua Co.		use of infiltration basins and absorption fields, and land application of biosolids. **Sec. 406.90** protects important geological features including sinkholes, caves, springs, springsheds, and so forth. Includes onsite protection, buffering standards, habitat function maintenance, use of BMPs, and mitigation of adverse impacts. **Sec. 406.91** provides special requirements for sinkholes, including management strategies for protection and restoration. **Sec. 406.92** provides protection for karst features, including requirements of a 3-ft distance between stormwater basins and limestone bedrock, studying water bodies to determine aquifer connectivity, subsurface channel analysis and regulations, and the stipulation that no septic systems are permitted in the subsurface channel area. **Sec. 406.101** prohibits discharge of waste or storm water into conservation management areas with some listed exceptions. **Sec. 406.113** minimizes adverse environmental impacts of storm and waste water by maximizing treatment processes and siting septic tanks and drainfields in places that will have the smallest impact on natural and historical resources.	
Comprehensive Plan, Conservation and Open Space Element	Alachua Co.		**Policy 3.5.3** states that LDRs will address surface and groundwater quality **Policy 3.6.8.2** sets minimum and average buffer widths for surface waters and wetlands of varying sizes **Policy 4.2.5** states that development will retain the natural character of important shallow groundwater tables. **Policy 4.2.8** states that stormwater outfall and irrigation connections must be designed to prevent erosion and sedimentation **Policy 4.3.1.3** LDRs will have provisions that minimize adverse impacts of mining on surface and groundwater quantity and quality **Policy 4.3.4** groundwater quality will not be significantly impacted through mining extractions. **Policy 4.4.4** pretreatment of stormwater and wastewater will be required prior to any discharge to any karst features.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
			Policy 4.4.5 provides for the protection of groundwater in watersheds with sinks or open pits that act as aquifer connections and are subject to harmful deposition of atmospheric and nonpoint source surface pollution. **Policy 4.4.6** provides for management of sinkholes and sinkhole-prone areas that will protect water quality, hydrologic integrity, and ecological value. **Policy 4.5.1** provides for the establishment of a wellhead protection program. **Policy 4.5.2** lays down standards that apply to public wells until wellfield protection areas are established, including a 200-ft zone with no new development allowed and uses that are prohibited in the vicinity of public wells. **Policy 4.5.4** suggests a possible tax reduction for property owners who agree to use their property only for genuine high-water recharge purposes as defined in the Florida Statutes. **Policies 4.5.5-7** protect groundwater in high aquifer recharge areas through suggesting restrictions on development, stormwater practices, hazardous materials, septic tanks, treatment plants, land use restrictions, and so forth. **Policy 4.5.8** requires that applicants for new development sufficiently address potential groundwater quality impacts. **Policy 4.5.10** requires evaluation of development that involves large withdrawals of groundwater, and states that the county will act to utilize reuse and reclaimed water as well as conserve water. **Policy 4.5.11** prevents the transfer of water out of the county except under emergency situations. **Policy 4.5.13** establishes a groundwater monitoring program that includes springs, with minimum requirements laid out in **policy 4.5.14**. **Policies 4.5.15-16** address abandoned or existing facilities that may be contaminating groundwater resources. **Policies 4.5.17-20** provide guidelines and limitations for redevelopment and restoration of contaminated sites, as well as the disposal of wastewater treatment effluent.	

Table 6-3. Counties and Local Municipalities with Policies and Comprehensive Plan Amendments applying to the Rainbow Springs and River and Rainbow Springs Basin

Policy/Regulations	Entity	Resource Protected	Type of Protection	Permit Approval
			Section 4.6 deals with surface water systems, including the protection of the hydrology and function of surface waters (4.6.4), buffering (4.6.5, 4.6.6, 3.6.8), maintenance of wetlands and native vegetation (4.6.7-8), controlling invasive species (4.6.9), creation of a water monitoring program (4.6.10), pollutant discharge (4.6.15), wastewater and stormwater standards/requirements (4.6.17-22), restoration of natural flows (4.6.24), and so forth. **Policy 7.4.2** sets standards for new and existing septic tanks.	

7 Causes of Impairment and Threats

The Rainbow River was declared impaired by FDEP in 2009 on the basis of the nitrate readings for the water emerging from the springs approaching and sometimes exceeding an average of 2.0 mg/L.

Threats to the Rainbow River

In 2009, members of the RSBWG discussed threats to the springs and river and made a decision to focus on three: increased nitrate pollution, decreased flow, and pressure on the ecosystem caused by recreation. In addition to these threats, there have been beach closings in recent years due to coliform bacteria readings that exceeded state health standards.

The three primary threats to the Rainbow River are described below.

Increased nitrate pollution: Nitrate levels measured in the Rainbow head springs now are regularly at or above 2.0 mg/L. This is more than 20 times the background level of <0.1 mg/L. Between 2000 and 2004, the nitrate concentrations averaged about 1.0 mg/L after 30 years of a steady rise from the background level. Therefore, in 30 years nitrate rose to 1.0 mg/L, and in the next 6 to 10 years nitrate rose to 2.0 mg/L.

Nitrates are a byproduct of many human activities including fertilization (agriculture, golf courses, lawns, etc.), and human and animal waste disposal practices. Nitrate emerging from Rainbow Springs is primarily inorganic, pointing to fertilizers as the origin. About 37% of the land in the Rainbow Springs basin is agricultural, so it is likely that much of the fertilizer is originating from agricultural activities. By contrast, only about 18% of the land is residential with less than 1% recreational (ball fields and golf courses). It should be noted, however, that the majority of this land use lies closer to the springs than the agricultural land uses. There is a full characterization of the land uses with maps and graphs in Section 9, Goals and Objectives.

Despite the rapidly rising nitrate, the river's ecosystem is still considered to be in a healthy state. The problems caused by increased nitrate are not completely understood although it may support increased algal growth as well as increased growth of the invasive exotic plant *Hydrilla*. Analysis by SWFWMD supports the theory that nitrate does fuel the growth of plantonic algae in the water column in the lower reaches of the Rainbow River (**Figure 4.9**, page 14). This contributes to a reduced water clarity which can decrease the productivity of SAV and potentially impact the entire ecosystem. Nitrate readings above 0.4 mg/L have been observed to cause toxic effects on macroinvertebrates.

Decreased flow: Flow from the Rainbow Springs Group has decreased over the last three to four decades although the range of flow today is within the range of all historical flows. Decreased flow can harm the ecosystem of the river due to lowered water levels. It can also exacerbate the impacts of dissolved nutrients by effectively increasing their concentrations. There has been lower than average rainfall in the last decade and possibly increased consumption of water for human uses. Scientists at the SJRWMD determined in late 2010 that flow data indicated the possible migration of groundwater from the Silver Springs basin towards Rainbow Springs perhaps due to the fact that Rainbow Springs is at a lower elevation than Silver Springs by 10

feet (unpublished data presented to the Silver Springs Basin Working Group by SJRWMD, November 2010).

Pressure on the ecosystem caused by recreation: Recreational pressure on the Rainbow River is intense. Two tubing operations (one county and one state) as well as boaters, divers, swimmers, and fishermen all use the river. On busy weekends it is very crowded. Competition for space can be intense, forcing people and boats into shallow areas and causing damage to the benthic environment, in particular SAV.

8 Vision for a Restored Rainbow Springs and River

A Vision for Rainbow Springs and the Rainbow River

Rainbow Springs and the Rainbow River form a healthy and sustainable natural system due to the deep connection and sense of stewardship of the community. A broad range of educational efforts have resulted in a voluntary reduction of land use impacts and water consumption in the spring basin. The ecosystem promotes a viable, self-sustaining community of fish, wildlife, and vegetation which supports low-impact recreational activities contributing to a diverse and sustainable economy. Water quality, specifically associated with nutrients including nitrates and phosphates, and water discharge are both maintained within parameters to support a healthy ecosystem. Informed citizens actively protect the basin through continued monitoring and research.

9 Goals and Objectives

Goals with some action steps for implementation are presented below in six categories: Biodiversity, Education and Outreach, Land Use and Development, Recreation, Water Quality and Water Quantity (Spring Flow). Appendix C contains the worksheets as completed by groups of stakeholders.

9.1 Biodiversity

Rainbow River has a rich biodiversity both within the stream and along the riparian corridor of the eastern shore. The majority of the western shore is developed and consists of houses and associated landscaping. Much of the western shore has hardened shoreline with numerous docks. The in-stream environment has a rich growth of native SAV dominated by *Sagittaria* sp. with *Vallisneria* sp. present in much smaller numbers. Interspersed with the SAV beds are bare sand and bare limerock. There is also a population of the invasive exotic aquatic plant, *Hydrilla*, which is regularly treated with chemicals to prevent its widespread growth. Data from surveys commissioned by the SWFWMD for 1996, 2000, and 2005 show *Hydrilla* makes up between 16 and 19% of the cover with the trend showing a slight increase (PBS&J 2007). During the same three surveys, the percent cover of *Sagittaria* sp., *Vallisneria* sp., and bare ground have not changed significantly. A new vegetation mapping study is currently underway (funded by SWFWMD). The results of this study are due to be released in 2012 and it will be important to compare the recent data with that of previous studies.

Available data on macroinvertebrates (SWFWMD 1995) did not allow a description of insects but did indicate several species of molluscs to be present together with crayfish (*Procambarus sp*), freshwater shrimp (*Palaemonetes paludosa*), and amphipods (*Hyalella sp*) (more recent data on macroinvertebrates from FDEP still to be examined). These invertebrates form the base of the food chain for the amphibian, reptile, and fish populations. Of the reptiles, the turtles have been most extensively studied with records dating back to the 1940s. Ongoing studies by Peter Meylan of Eckerd College continue this work today. Since 1990, the most common species present on the river is the loggerhead musk turtle (*Sternotherus minor*), making up more than 60% of the total turtle population and which was not present in the 1940s surveys. Seven other species are found on the river (listed from most common to least) including eastern river cooter (*Pseudemys concinna)*, Florida cooter (*Pseudemys floridana)*, common musk turtle (*Sternotherus odoratus)*, Florida red-bellied cooter (*Pseudemys nelsoni)*, Florida softshell turtle (*Apalone ferox)*, striped mud turtle (*Kinosternon baurii)*, and chicken turtle (*Deirochelys reticularia*). In 2009, FWC passed a rule preventing harvest of turtles in the Rainbow River in response to a sharp increase in turtle hunting to supply foreign markets with turtle meat.

There is a diverse fish population with 20 species represented. Biomass present is dominated by fish of the family Centrarchidae (various species of sunfish and largemouth bass) with the mosquito fish (*Gambusia holbrooki*) being the most abundant, according to a survey by Walsh and Williams in 2003.

The river supports a diverse bird population, both aquatic feeders (swimmers, divers, and waders) and forest birds living in the forested riparian habitat along the eastern shore. Otters are a common sight on the river. Manatees are effectively blocked from the Rainbow and upper

Withlacoochee rivers by the dam that forms Lake Rouseau. The last report of a manatee in the Rainbow River was in 1976.

Threats to the biodiversity of the Rainbow River include the possibility of increase in invasive exotic plants such as *Hydrilla* and *Lyngbya*, unregulated recreation that might damage the benthic environment, over fishing, and continued development along the river corridor. None of these pose an immediate threat although the intensity of recreation is causing concern for the status of SAV. The biodiversity of the river clearly affects the quality of the recreational experience indicating that attention to protecting the biodiversity is important.

A study done in 1994 by researchers from UF (Holland and Cichra 1995) attempted to determine if recreational activity represented a threat to the health of SAV. While positive correlations were found between the recreational activities of all user groups with the amount of displaced SAV, the authors concluded that the amount of SAV being disturbed and sent down river was insignificant compared to the total biomass of SAV together with its ability to reconstitute itself through reproduction and growth.

In 2011, a new study was commissioned and funded by the SWFWMD and FDEP and is under way at the time of writing. Professor Holland from the University of Florida is once again the principal researcher for this study. The number of visitors recreating on the river has increased, and many local citizens are convinced that SAV is now being significantly damaged. This study is using cameras to record visitor behavior in six locations on the river in an effort to capture the degree to which visitor behavior represents a cause of damage to SAV. The results of this study are expected in 2012.

Goals

1. Restore the diversity and quantity of native flora and fauna in the Rainbow River system.
2. Reduce and control invasive exotic flora and fauna in the Rainbow River system.
3. Preserve and increase populations of federally or state listed species.

Goals with Suggested Actions

1. Restore the diversity and quantity of native flora and fauna in the Rainbow River system.
    - Conduct floral and faunal inventories.
    - Compare results of completed vegetation/recreation study being conducted by UF in 2011 with a previous study by UF on the same topics, conducted in 1994.
    - Based on assessment of the vegetation/recreation study, implement use of zoning in the river as needed to protect biodiversity.
    - Identify species in need of specific management actions and determine needed actions.

2. Reduce and control invasive exotic flora and fauna in the Rainbow River system.
    - Inventory location and extent of invasive exotic species based on the results of the SWFWMD vegetation mapping study due to be completed in 2011.
    - Develop education and enforcement programs on invasive exotic species targeting river access locations as points of delivery.
    - Research potential solutions to remove or control *Lyngbya*.

3. Preserve and increase populations of federally or state listed species.

9.2 Education and Outreach

Education and outreach programs that inform citizens about issues associated with the protection of groundwater and springs are widely thought to be an important element of springs protection. It is generally assumed that people do not intentionally use too much water or fertilizer and that they usually do not realize their actions might cause damage. Many people assume their own actions are too insignificant to make a difference. It is hoped that education will fill these gaps and provide people with the necessary information that will guide their future behavior. The extent to which this is true is in some dispute. See discussion of social marketing below.

Education programs that target water conservation and fertilizer reduction in the Rainbow Springs basin are available from the SWFWMD, Marion County, some nonprofit groups, and a variety of one-time events such as Earth Day festivals. SWFWMD offers the following programs: Know Where it Flows, assistance to teachers through educational materials and resources as well as *Splash* mini-grants for proposed projects, community grants for educational projects proposed by nonprofit and civic groups, a Speakers Bureau, free materials for any group that requests them, training for Project Wet and other programs, and a variety of web-based learning tools. SWFWMD has also sponsored special springs awareness events that have included field trips to see the karst features within a springs basin and storm drain marking to make it clear where the stormwater will go once down the drain.

Best Management Plans (BMPs) for farmers, produced by the Florida Department of Agriculture and Consumer Services, include education as a major component. There are several BMP manuals relevant to the protection of the Rainbow Springs; Florida Cow/Calf Operations, Vegetable and Agronomic Crops, Manure Application, Florida Container Nurseries and Florida Specialty Fruit and Nut Crops. A new Florida Equine BMP manual has been developed and awaits final approval.

Marion County has developed a variety of educational materials and programs for use at public events and other functions. *Be Wise When You Fertilize* is a public service announcement designed to encourage people to use less fertilizer and was created after the Fertilizer Ordinance was passed in 2009. The Marion County Extension program offers numerous educational programs to foster the protection of groundwater and springs. The Clean Farms Program informs equine farm owners one-on-one about manure management and proper care and fertilization of pastures using best management practices (BMPs). The Florida Master Gardener Program trains people to become educators about low input gardening techniques. The Sustainability Program, a new Marion County Extension program, informs about a variety of sustainability issues and received funding from the Protect Florida Springs Tag Grant Program, in partnership with the springs working groups, to develop a groundwater awareness and springs protection module during the next fiscal year.

The Marion County Springs Festival, coordinated by a consortium of organizations sponsors a springs festival in September of each year with a mix of educational and entertaining events. There was an Earth Day event at Silver River State Park in 2011, and SWFWMD has sponsored Springs Awareness Month events in the springs basin in recent years. Rainbow River Conservation has developed and distributed materials about the negative impacts of excessive recreation on the river, including a video and a brochure. The group holds meetings in Dunnellon

that include speakers discussing groundwater and springs protection. The RSBWG has included numerous speakers in its quarterly meetings and has produced a poster that raises awareness about the springs basin and the need for careful stewardship of water resources (assistance received from SWFWMD and the Protect Florida Springs Tag Grant Program). A small committee of working group members is coordinating distribution of the posters and the working group coordinator has given several presentations to civic groups.

Research on a variety of education programs from many areas has led some educators to conclude that traditional education programs often are unsuccessful in changing behavior (McKenzie-Mohr and Smith 1999). Most people apparently do not change behavior simply because they know that what they are doing will cause damage. It appears that other factors such as convenience may be more important. Social science research demonstrates that behavior change is most effectively achieved when barriers to a sustainable activity are removed, and its benefits are seen for the community, resulting in more people engaging in the activity. This has led to the development of a relatively new form of education called social marketing. It is based on the successes of marketing firms to get people to change their purchasing behavior when shopping for products. The method was adapted to health education programs and was widely credited with being a major factor in causing the rate of smoking to drop among the American population. Social marketing programs involve traditional educational techniques but are designed specifically to change behavior rather than simply inform. To be effective, programs must be carried out at the community level and involve direct contact with people.

Goals

1. Educate stakeholder groups on ways to improve the water quality in the Rainbow Springs basin.
2. Conduct an aggressive public education program on the benefits of water conservation in Rainbow Springs basin.
3. Develop a set of easy to interpret graphics (graphs, figures, images) that clearly depict water quality and quantity data for use in education programs.
4. Develop materials that interpret and explain TMDLs and MFLs in a way that can be readily understood by the public. Provide this information for the Rainbow River in ways that prevent misinterpretation.
5. Erect signs within the Rainbow Springs basin that raise the awareness of the geographic location of the springs basin.

Goals with Suggested Actions

1. Educate stakeholder groups on ways to improve the water quality in the Rainbow Springs basin.
    - Inventory existing education programs to identify possible overlaps and new programs needed.
    - Assess audiences for different aspects of the education program and develop appropriate messages specific to each group.
    - Maintain existing educational efforts: Clean Farms, teacher trainings, Know Where it Flows, etc.
    - Create a specific curriculum for the Rainbow Springs basin for schools.

- Create neighborhood programs promoting landscape BMPs, specifically for fertilizer use.
- Coordinate a forum for decision-makers on the economic impacts of poor water quality vs. improved water quality.

2. Conduct an aggressive public education program on the benefits of water conservation in the Rainbow Springs basin.
   - Build this goal into the actions listed above for water quality where appropriate.

3. Develop a set of easy to interpret graphics (graphs, figures, images) that clearly depict water quality and quantity data for use in education programs.
   - Assess graphics already produced and determine most appropriate format.
   - Develop graphics and make available to educational entities.
   - Regularly update statistics.

4. Develop materials that interpret and explain TMDLs and MFLs in a way that can be readily understood by the public. Provide this information for the Rainbow River in ways that prevent misinterpretation.
   - Assess any educational material already developed.
   - Develop new materials and make especially relevant to the Rainbow Spring basin.
   - Determine groups and individuals that can effectively deliver these materials.
   - Implement programs with the new materials.

5. Implement a program to encourage farmers to adopt the appropriate BMPs on their lands.
   - Complete the approval process of the new Equine BMP manual
   - Through all appropriate means, contact farmers and work with them to encourage adoption of BMPs appropriate to each land use
   - Have 80% of all eligible farmers adopt appropriate BMPs by 2016.

6. Erect signs within the Rainbow Springs basin that raise the awareness of the geographic location of the basin.
   - Assess the number of signs already erected and location of these signs.
   - Assess locations that do not currently have signs.
   - Create and erect new signs as needed.
   - Maintain signs at each location and replace as needed.

9.3 Land Use and Development

The dominant land use in the Rainbow Springs basin is agriculture (see **Figure 4-3**). Cow calf operations and equine facilities make up the majority of this land use classification in western Marion County and eastern Levy County. There is also some acreage devoted to raising row crops, and some small areas have nurseries. There is a substantial amount of forested land that is not used for agricultural production. Suburban development is the dominant land use close to the springs, both along SR 41 and also SR 40. There is one large platted development (Rainbow Lakes Estates) and several smaller ones (e.g., Lake Tropicana) that are less than 50% built out at this time. Much of the undeveloped lots are upland pine with sandy soils that make excellent filtration areas for aquifer recharge. Much of the agricultural land use area in the northwestern part of Marion County is classified as an Agricultural Protection Zone in the Marion County Comprehensive Plan.

In 2009, the population of Marion County was estimated to be 328,547 (61% urban, 39% rural) by the US Census Bureau. Population was projected by the Florida Statistical Abstract, to steadily rise to 651,400 by 2055 (high estimate) with a median estimate of just under 500,000 and a low estimate very close to 350,000. If the high estimate comes true, many land use changes will occur by mid-century.

Marion County has in place a Springs Protection Ordinance that specifies guidelines for development and disallows various types of development in a primary protection zone (**Figure 9-1**). The objective of the Springs Protection Ordinance is as follows:

> *…to preserve the quantity and protect the quality of the Floridan Aquifer underlying all of Marion County and to protect the environmental, recreational, and economic values of Silver Springs and Rainbow Springs in the interest of public health, safety and general welfare. This is to be accomplished by regulating land uses and activities which can adversely impact the quality and quantity of groundwater within the identified Springs Protection Zones (SPZ).*
> From the preamble.

The ordinance provides guidelines for stormwater and wastewater treatment to a more stringent standard than on properties outside the SPZ. It also provides specific guidelines for the protection of karst features and for areas of high groundwater recharge potential. Initially the county specified secondary protection zones with less stringent requirements but later amended this to include the whole county, (outside of a primary zone) as a secondary protection zone. A county Landscape Ordinance protects native landscaping and provides for certain tree removal projects to be permitted. This assists with protection of aquifer recharge and the protection of stormwater runoff. The Marion County Comprehensive Plan includes language that supports establishing a Transfer of Development Rights program to protect sensitive areas of high groundwater recharge. This has not been implemented in the Land Development Codes.

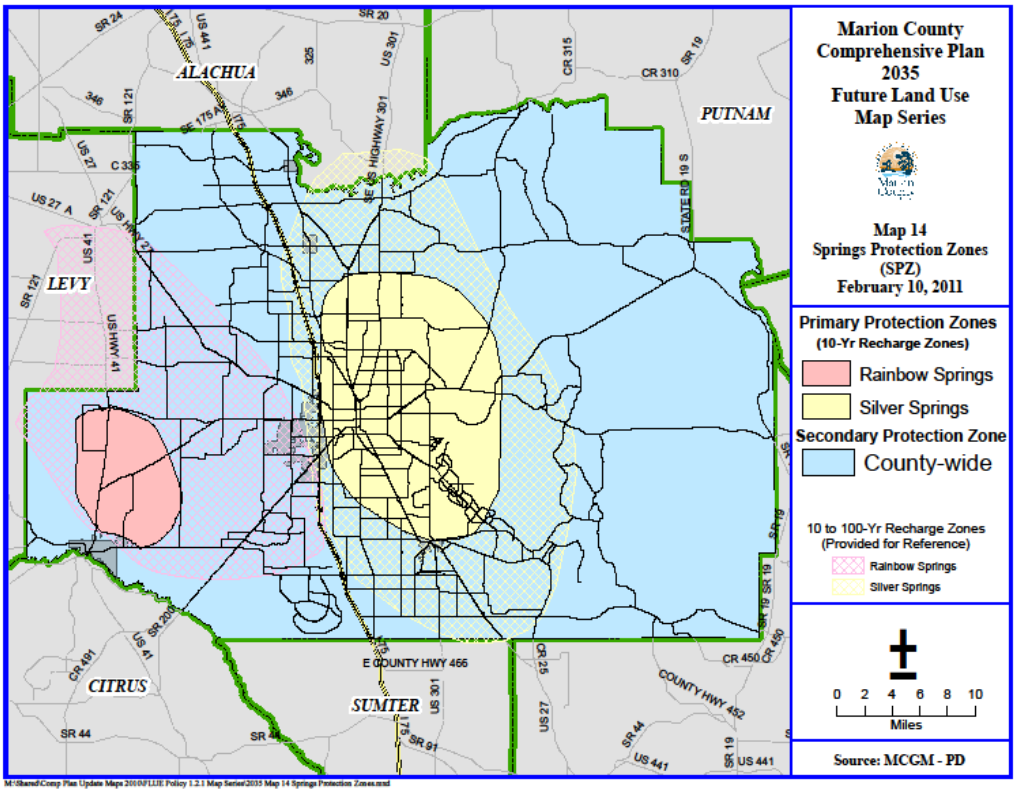


Figure 9-1. Marion County springs protection zones.
Source: Marion County

Levy County's Comprehensive Plan includes language supporting the establishment of a Springs Protection Zone around Fanning and Manatee Springs but has nothing similar for the eastern part of the county in the Rainbow Springs basin. The City of Williston includes some springs protection elements in its comprehensive plan including policies to prevent impacts to "aquifers and groundwater characteristics," to prevent runoff of untreated stormwater into sinkholes, and to protect soils during development to protect groundwater recharge.

Both Marion and Levy counties have determined the vulnerability of the Floridan Aquifer to pollution from surface runoff. The Aquifer Vulnerability Assessments classified lands slightly differently for each county; however, both maps show that the entire Rainbow Springs basin is either "vulnerable" or "most vulnerable" with the land closest to the springs being "most vulnerable" (see **Figures 4-6 and 4-7**).

Goals (Note: The Land Use and Development Goals and Actions for Rainbow Springs and Silver Springs Restoration were combined.)

1. Using all available information (including Marion and Levy County Aquifer Vulnerability Assessments and known locations of major karst features), identify significant groundwater recharge areas, karst sensitive areas, and areas important for springs protection. Consider adding these areas to the Primary Protection Zone for either Silver or Rainbow Springs wherever feasible.
2. Ensure the development and maintenance of vegetated buffers along all swales and waterbodies.
3. Develop incentives for landowner protection of aquifer recharge areas including less than perpetual easements, density bonuses for clustering, and payment for ecosystem services – incentives that work in alignment with the financial structure of the landowner.
4. By 2020, retrofit existing stormwater systems and drainage ways to reduce nutrient runoff and minimize impacts on aquifer recharge. Convert to biological stormwater treatment areas (STAs) where practical and applicable.
5. By 2105, ensure all new STAs built within the Rainbow and Silver Springs basins are biological STAs.
6. Promote use of existing programs and develop new programs where needed to provide public recognition to managers of large facilities such as golf courses, housing developments, or farms that have demonstrated nutrient reduction and habitat conservation programs.
7. Fully implement Marion County's Springs Protection Ordinance to protect groundwater quality through the regulation of land use activities in the primary protection zones.
8. By 2020 ensure that all new developments use water saving fixtures (toilets, faucets and sprinkler systems) at the highest level of efficiency available.
9. Upgrade existing wastewater treatment facilities to advanced wastewater treatment (AWT) and require new wastewater treatment facilities in the Rainbow and Silver Springs basins to operate at an AWT standard and provide reuse water to nearby facilities. Require golf courses in the springs basin to use reuse water from wastewater treatment facilities when available.
10. Implement regulations by 2020 to ensure all high density developments within the springs basin are connected to a wastewater treatment system, preferably with advanced treatment.
11. By 2013, identify parcels in the Rainbow and Silver Springs basins contiguous to public lands or with natural resource significance to groundwater recharge and springs protection for potential acquisition or for conservation by other means including conservation easements, mitigation, donation, or payment for ecosystem services.
12. Develop and implement a policy in transitional areas (areas that might move from a more rural use to a more urban use) that provides incentives for conservation and water quality protection to private landowners.
13. By 2020, ensure all jurisdictions within the Rainbow and Silver Springs basins offer density bonuses for cluster development as well as for "purple pipe" reuse systems and gray water systems.
14. By 2020, ensure all developments within 1 mile of the Rainbow River and Springs are hooked up to central water and sewer systems.

Goals with Suggested Actions

1. Using all available information (including Marion and Levy County Aquifer Vulnerability Assessments and known locations of major karst features), identify significant groundwater recharge areas, karst sensitive areas, and areas important for springs protection. Consider adding these areas to the Primary Protection Zone for either Silver or Rainbow Springs wherever feasible.
   - Pay particular attention to areas prone to sinkhole formation.
   - Design all STAs carefully to ensure collapse is avoided.
   - Prohibit any untreated stormwater runoff from reaching sinkholes and other direct connections to the Florida Aquifer.
   - Ensure all STAs are regularly inspected to avoid failure of systems.
   - Ensure all appropriate regulatory mechanisms are in place such as a "karst sensitive rule" to protect against inappropriate development in karst sensitive areas.

8. By 2020 ensure that all new developments use water saving fixtures (toilets, faucets and sprinkler systems) at the highest level of efficiency available.
   - Marion and Levy counties and the cities of Belleview, Dunnellon, Ocala, and Williston should add language to their comprehensive plans and land development codes if not already included.

10. Implement regulations by 2020 to ensure all developments within the springs basin are connected to a wastewater treatment system, preferably an AWT system.
    - Marion and Levy counties and the cities of Belleview, Dunnellon, Ocala, and Williston should add language to their comprehensive plans and land development codes if not already included.

13. By 2020, ensure all jurisdictions within the Rainbow and Silver Springs basins offer density bonuses for cluster development as well as for "purple pipe" systems and gray water systems.
    - Marion and Levy counties and the cities of Belleview, Dunnellon, Ocala, and Williston should add language to their comprehensive plans and land development codes if not already included.

14. By 2020, ensure all developments within 1 mile of the Rainbow River and Springs are hooked up to central water and sewer systems.
    - Assess current situation and identify all properties within the one-half mile buffer on septic and well vs. municipal water and sewer systems.
    - Develop plan to implement the needed hookups.
    - Seek funding necessary to implement the needed hookups.

9.4 Recreation

The Rainbow River is very popular for many forms of recreation. On a busy weekend, the river can become packed with pontoon boats, dive operators, small power boats, canoes, kayaks, and tubers (**Table 9-1**). People engage in boating, diving, swimming, fishing, tubing, and wildlife viewing. Boating includes various activities such as being towed behind a boat on a float. There is also swimming at the Rainbow Springs State Park (RSSP) in a cordoned off swimming area as well as at a private beach for members of the Village of Rainbow Springs Property Owners Association. Residents and visitors along the western shoreline as well as in a few places on the eastern shoreline can also access the river from privately owned docks.

There are many additional access points. Boats can enter the river by coming upstream from the Withlacoochee River or by using a public boat ramp (in Dunnellon and at KP Hole County Park). RSSP does not allow motorized vessels to approach the head springs. Canoes and kayaks can be rented at the state park, and many private operators bring in parties of people by the van load for a canoe or kayak outing on rental boats. There are two separate tubing operations: one associated with RSSP on the eastern shore and the other with KP Hole on the western shore under the management of Marion County Parks and Recreation (MCPR) (**Table 9-2**).

While access is very open, user rules are quite strict. No alcohol and no disposable items are allowed on the river. On a recent outing on the first Saturday for tubing at KP Hole in 2011, the author observed the rules being followed almost exclusively.

There is concern that the recreational pressure is harming the integrity of the river system. First, tubers are likely to stand in shallower areas and also walk on the bottom. This can break off and uproot SAV – the basis of biological productivity. Second, the sheer number of boat and tubes can cause traffic jams that cause some motorized vessels to veer into shallow water and potentially damage SAV. Third, groups of divers and snorkelers can disrupt the bottom and increase damage with flippers. Fourth, disruption of the river bottom can encourage the spread of the invasive exotic plant *Hydrilla*. Last, the crowded conditions on some busy weekends might disrupt fish and wildlife behavior patterns.

Table 9-1. Rainbow Springs State Park Visitor Statistics

Year	Head Springs Area	Tubers	Campers	Total
2009	172,811	24,486	19,026	216,323
2010	162,358	44,002	42,648	249,008
2011 (YTD)	56,894	3,524	17,633	78,051

Note: Canoe and kayak rental statistics not available

Table 9-2. Marion County Parks and Recreation Visitor Statistics for KP Hole

Fiscal Year	Diver/Snorkler	Floater	Regular	Boat Launch	Total
2009/2010	10,893	39,830	13,061	12,132	75,916
2010/2011 (YTD)	4,019	170	1,788	2,765	8,742

A study done in 1994 by researchers from UF (Holland and Cichra 1995) attempted to determine if recreational activity was negatively impacting SAV. While positive correlations were found between recreational activity of all user groups with the amount of displaced SAV, the authors concluded that the amount of SAV being disturbed and sent down river was insignificant compared to the total biomass of SAV together with its ability to reconstitute itself through reproduction and growth.

In 2011, a new study was commissioned and funded by the SWFWMD, Marion County and FDEP and is underway at the time of writing. Professor Steven Holland from the University of Florida is once again the principal researcher. The number of visitors recreating on the river has increased, and many local citizens are convinced that SAV is now being significantly damaged. This study is using cameras to record visitor behavior in six locations on the river in an effort to capture the degree to which visitor behavior represents a cause of damage to SAV.

Goals

Protect the aquatic resources of the Rainbow River system while promoting sustainable recreational uses.

Goals with Suggested Actions

Protect the aquatic resources of the Rainbow River system while promoting sustainable recreational uses.

- Educate user groups about the fragile ecosystem.
- Determine a carrying capacity for users of the river.
- Examine opportunities to use spatial and temporal zoning to reduce recreational impacts to the aquatic community of the river.
- Develop strategies to reduce conflicts among users while they are on the river.
- Examine commercial use of the river, both levels of use and any impacts to the river.
- Determine if there is an appropriate quantity and quality of public access to the river.
- Examine the impacts specific to the wildlife associated with the river.
- Survey visitors' experiences on the river to determine level of user comfort and satisfaction.

9.5 Water Quality

Prior to 1960, nitrate levels for Rainbow head springs were below 0.1 mg/L, the so-called background level for groundwater in the Floridan Aquifer. Since then, nitrate concentrations have risen to the current level that fluctuates at a point approaching 2 mg/L, between a 10 and 20 fold increase (see **Figure 4-8**). Half of that rise has occurred since 2000 when the nitrate level was approximately 1 mg/L indicating an acceleration of increase. Based upon this, a projection of 4 mg/L is not unreasonable for the year 2020. Rainbow River was listed as impaired by FDEP in 2010, primarily due to the rising nitrate.

Nitrogen is an important nutrient needed by all living organisms and is readily metabolized into different forms (ammonia, nitrate, nitrite and atmospheric gas). It is constantly cycled through living organisms and is a primary constituent of liquid waste from all animals, including humans. It is also an important constituent of all fertilizers to promote plant growth. Data gathered by SWFWMD indicate that most nitrate dissolved in the waters of the Rainbow River is from an inorganic source, which points to fertilizer as the primary source (SWFWMD 2008, Jones et al 1996). Fertilizers are applied by farmers, landscape professionals, homeowners, and golf course managers but available data do not allow a detailed analysis of which of those land uses are contributing the majority of the problem in the Rainbow River. More than 95% of the flow of the Rainbow River comes from the springs; therefore, the source is groundwater that has come from the springs basin. Most of the Rainbow Springs basin has an unconfined aquifer meaning that surface water percolates down to it through sandy soils with no barrier to slow its passage. Both the Marion and Levy county Aquifer Vulnerability Assessments show the aquifer to be either "highly vulnerable" or "most vulnerable" throughout most of the Rainbow Springs basin. Any nitrate that leaves the "root zone" (the upper layers of soil that roots penetrate) and moves down towards the aquifer will change little until it emerges from a spring and once again becomes biologically active. It is therefore necessary to examine land uses in the springs basin to derive estimates of the sources of nitrogen.

Figure 9-2 indicates that natural area/water forms the largest segment of land use followed by crop and pasture, residential low density, and the specialty farms (equine farms). Most of the specialty farms are essentially pasture, so combining this category with crop/pasture and also row crop results in 37% for agricultural land uses (slightly more than one-third of all the land use in the springs basin). Given these land uses, it is reasonable to assume that a significant portion of the nitrate in the springs is derived from agricultural fertilizers. In 2010, no farms in the springs basin were officially listed with the Florida Department of Agriculture and Consumer Services (FDACS) as being signed up for one or more BMPs. The recreational category includes golf courses (about 800 acres), well known for using large amounts of fertilizers, and ball fields (about 330 acres). There are three golf courses in the Rainbow Springs basin, comprising less than 1% of land use. All three courses are within 2 miles of the springs. All follow BMPs for golf courses, and one, Juliette Falls, is certified by Audubon International. Combining recreation with low, medium, and high density residential produces about 18% of the land use, less than one-half the figure for agriculture. The majority of the residential land is serviced by onsite sewage treatment (septic), a system which does little if anything to remove nitrogen. A map of septic tanks in Marion County is shown in Appendix A.

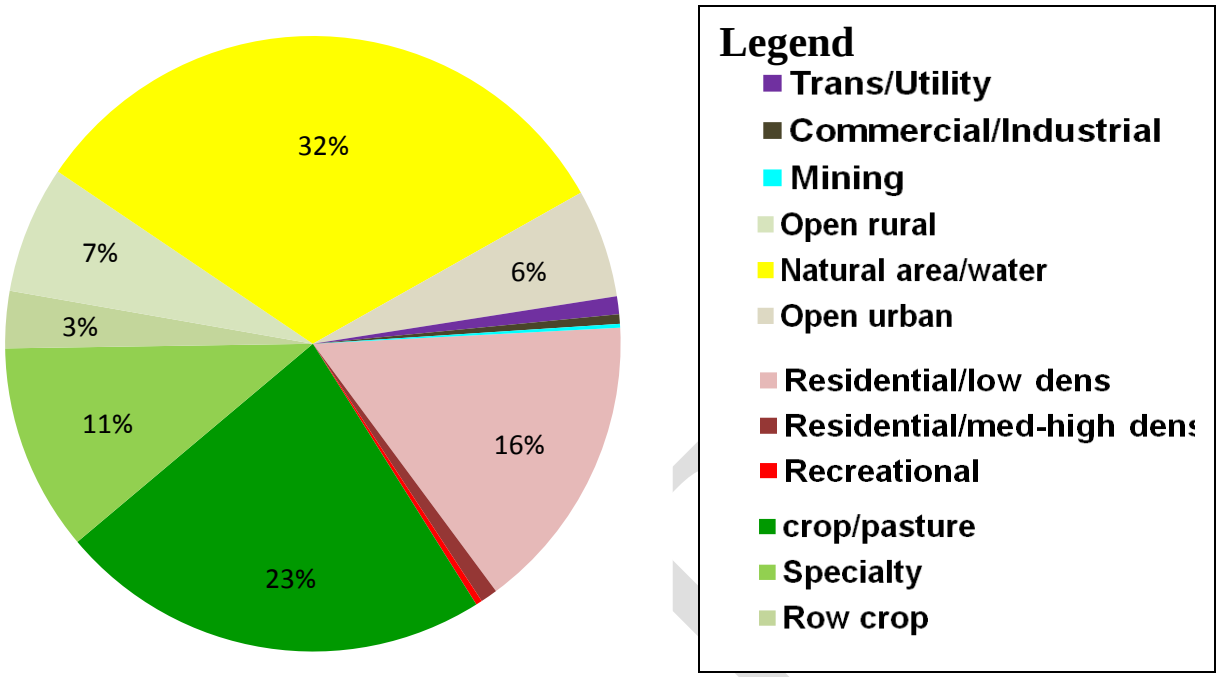
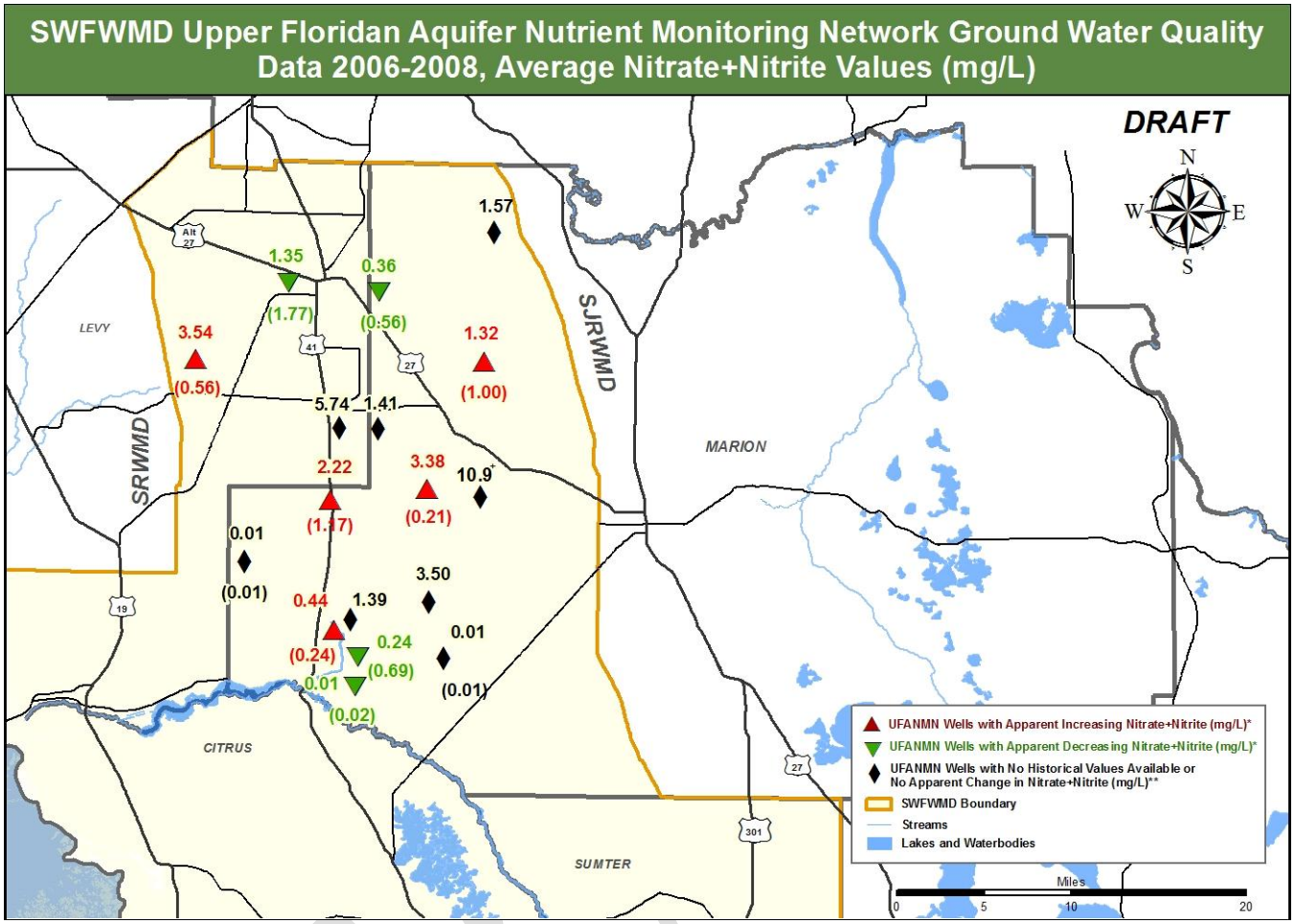


Figure 9-2. Land uses in the Rainbow Springs basin, 2009.
Source: SWFWMD (draft data)

Monitoring wells in the Rainbow Springs basin provide estimates of nitrate concentrations within the Upper Floridan aquifer. **Figure 9-3** shows that wells in the basin in 2006-2008 had nitrate concentrations that ranged from a low of 0.01 mg/L to a high of 10.9 mg/L.

A Watershed Assessment Model (WAM) simulates surface and groundwater flow and water quality, including nutrient loads from sources on the surface and appropriate attenuation processes along the flow path (HDR 2008). The WAM modeling approach can include consideration of closed sub-basins typical of karst terrains with no surface outlet as well as the resulting groundwater flow and nutrient transport. This makes the methodology particularly useful for groundwater modeling of nutrient contamination within a springs basin.

As part of a comprehensive springs protection planning effort by Marion county, in cooperation with the SWFWMD, the WAM approach was used to model nutrient transport within the Rainbow Springs basin in 2008 (HDR 2008). A GIS-based computer model was developed to simulate water and non-point source pollution discharges from Rainbow Springs and to spatially quantify sources of nitrogen, the pollution of greatest concern. There were three land use scenarios developed and simulated using the WAM, a base-run to show the present existing condition and two future scenarios to simulate changes. The base run or "existing condition run" was based on 2007 land use coverage which was actually 2005 land use data updated to reflect 2007 tax assessment data and aerial verification. The next two scenarios used future land use



All values listed represent nitrate+nitrite concentrations in mg/L.

* Values listed without parentheses represent the average of nitrate+nitrite values available from current data (February 2006 to January 2008). Values within parentheses represent the average of nitrate+nitrite values available from historical data (June 1994 to October 2005). Apparent increasing and decreasing concentrations were determined from a comparison of the mean historical nitrate+nitrite values to the mean of the current nitrate+nitrite values.

**Values listed without parentheses represent the average of nitrate+nitrite values available from current data (February 2006 to January 2008). Values within parentheses represent the average of nitrate+nitrite values available from historical project data (June 1994 to October 2005). No apparent increase or decrease in the nitrate+nitrite concentrations was able to be determined from a comparison of the mean historical nitrate+nitrite values to the mean of current nitrate+nitrite values. For wells with only current data available the average of the nitrate+nitrite values is given.

+Best Management Practices are currently being implemented at this site.

Figure 9-3. Average Nitrate + Nitrite values in selected wells within the Rainbow Springs basin.
Source: SWFWMD

predictions for 2025 and 2055, using data provided by Marion County. The future land use scenarios were based on the premise that a utility zone with central sewer will be developed in the basin.

The result of the modeling is shown in **Figure 9-4**. It shows the predicted trends in nitrate contamination that are anticipated to occur as the Rainbow Springs basin develops. The red trend line shows the current nitrogen trend in the springs based on measured data, while the light blue trend line indicates what would happen if 2007 land use within the springs basin were never altered. The green trend line shows the anticipated nitrogen increases in the springs based on predicted future land uses. The nitrogen levels in the springs are likely to reach about 5 to 6 ppm by 2055, as compared to about 1.7 ppm currently observed in the Rainbow River (HDR 2008).

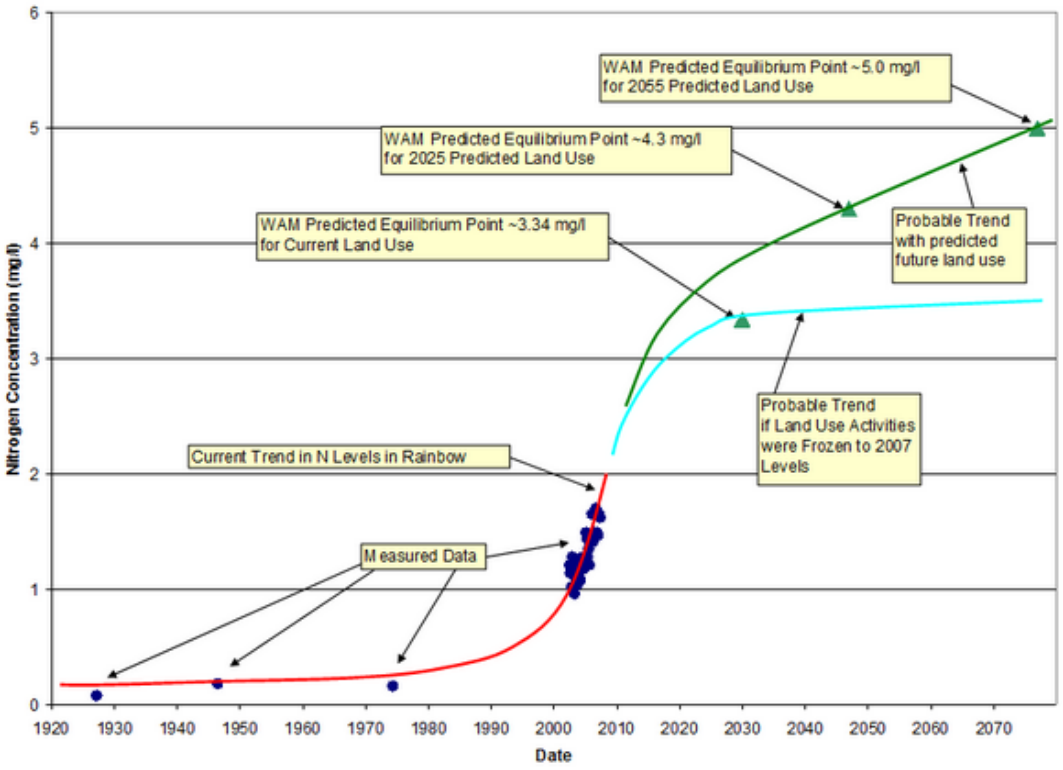


Figure 9-4. Watershed Assessment Modeling for nitrate trends in the Rainbow River
Source: HDR, 2008

Most wastewater within the Rainbow Springs basin is treated via onsite sewage disposal systems (septic tanks). There are some small "package plants" that service the communities near Rainbow Springs although none of them are operated by Marion County Utilities. The City of Williston has a Wastewater Treatment Plant which supplies effluent to a sprayfield close to US Highway 41 and about 14 miles directly north of Rainbow Springs. According to sources at the city, the sprayfield distributes an average of about 200,000 gallons of effluent daily with an average dissolved nitrate concentration of 2 mg/L. The Williston plant is a Class 3C facility, not a Class 1 and therefore does not have advanced treatment. Two mg/L is a surprisingly low nitrate reading for a Class 3C facility so further investigation may be needed to corroborate the nitrate concentration. Quarterly data from 4 monitoring wells close by the spray field obtained by DEP indicated an average concentration of 1.43 m/L nitrate + nitrite over a 10 year period from March 1999 to December 2010.

In 2006, there were 54, 219 septic tanks operational in Marion County (Appendix A). About 10,000 of these are within 10 miles of Rainbow Springs. However, according to data received from the Marion County Planning Department there are also approximately 30,000 vacant lots within 10 miles of the springs, most within the Primary Springs Protection Zone, and most on land which currently is classified as "natural" on the basis of a lack of either agricultural or forestry activities. The majority of this land is rated as "highly vulnerable" according to the Marion County Aquifer Vulnerability Assessment (**Figure 4-6**). These lands have already been approved for development with septic tanks (**Figure 9-5**).

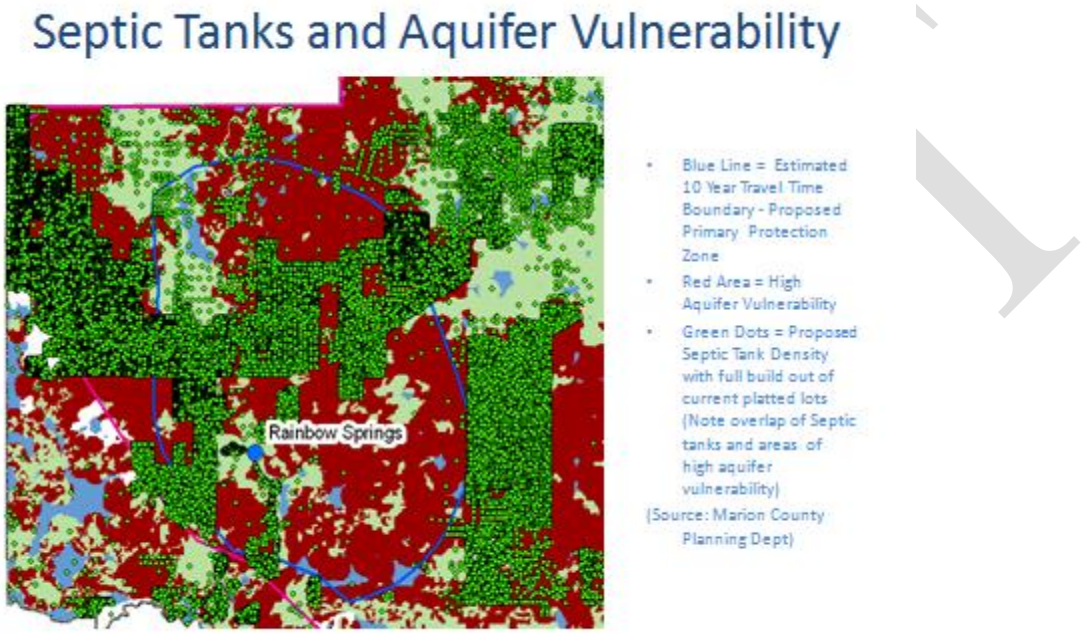


Figure 9-5. Projected number of septic tanks needed to serve full build out of the development already platted within about 10 miles of Rainbow Springs.
Source: Marion County Planning Department

The Marion County Planning Department calculated nitrate loading from septic tanks and estimated that the 10,600 tanks currently in operation produce between 25 and 36 lbs per year per tank for a low estimate of 133 tons to a high estimate of 191 tons (**Table 9-3**). The low estimate assumes efficient operation, while the higher estimate assumes a lack of maintenance such as pumping which is common for septic tanks. Full build out of the vacant lots with septic service would put 39,500 tanks into operation within 10 miles of Rainbow Springs and produce between 494 to 711 tons of nitrogen per year.

Table 9-3. Nitrogen Loading Estimates for Septic Tanks within 10 Miles of Rainbow Springs

	25 lbs per year	**36 lbs per year**
10,600 tanks (current)	132.5 tons per year	190.8 tons per year
39,500 tanks (full build out)	494 tons per year	711 tons per year

Source: Marion County Planning Department

Draft calculations for nitrate loading estimates at Rainbow Springs, based upon work done by staff of the SWFWMD, are shown in Appendix B. Nitrogen loading is calculated based on nitrate concentration and volume of water. Using this methodology provides an estimate of nitrogen loading for the Rainbow River from groundwater emerging from the springs at present of about 1,000 tons per year equivalent to about 2.7 tons per day. In order to cause a decrease in nitrate loading, it will be important to calculate nitrate loading rates based on the different land uses and then allocate reductions based upon those calculations. The TMDL and resulting BMAP will calculate nitrate loading based on different land uses.

It should be noted that there is a relationship between spring flow (water quantity) and water quality. If spring flow declined dramatically, the residence time for water in the river would increase, which could result in an increase in nutrient assimilation by nuisance plants and algae. Another important factor to consider in this analysis is the age of the water emerging from the springs and, therefore, the age of the nitrate. Analysis of the age of the water emerging from the Rainbow Springs Group shows that the water is of variable age between 1 and 30-years old. This indicates that nitrate dissolved in the water will also be a mix of ages, some being applied to land within the last year or two and some being applied to the land as long ago as 1980.

Goals

1. By 2016, halt the increasing trend in nitrate concentrations in the Rainbow Springs Group that is present in 2011.
2. Reduce nitrate levels as measured at the springs vents to below 2 mg/L by 2020. (This provides for some restoration in addition to the first goal which is more focused on protection).
3. Implement a program to encourage widespread adoption of BMPs in the Rainbow Springs basin that results in at least 80% of the farms in all categories adopting BMPs.

Goals with Suggested Actions

1. By 2016, halt the increasing trend in nitrate concentrations in the Rainbow Springs Group that is present in 2011.
    - Encourage farmers to develop and embrace nitrogen reduction strategies and Nutrient Management Plans. As a part of this work, enroll at least 10 agricultural landowners per year operating within the spring basin into an appropriate BMP program
    - Establish nitrogen TMDL and initiate a BMAP for the springs basin.
    - Implement the Marion County Watershed Assessment Model (WAM).
    - Identify areas of localized high groundwater recharge, closed depressions, sinkholes, and swallets that may provide rapid transport of nutrients and other pollutants to springs.
    - Reduce loading contributions from septic tanks with responsible maintenance, inspections, improved technology, and retrofits.
    - Expand reclaimed/reuse water availability.
    - Quantify the economic impact of increased nutrients: How much will it cost to do nothing?
    - Provide easily understandable information and presentations on Rainbow Springs and water quality to a wide audience: schools, public officials, and the general public.
    - Improve stormwater retention and treatment for nutrient reduction, applied to new systems and retrofit of existing structures.

- Reduce stormwater volumes and nutrient loads in runoff water.
- Continued water-quality monitoring and assessment of springs and groundwater in the basin.

2. Reduce nitrate levels as measured at the springs vents to below 2 mg/L by 2020. (This provides for some restoration in addition to the first goal which is more focused on protection).

3. Implement a program to encourage widespread adoption of BMPs in the Rainbow Springs basin that results in at least 80% of the farms in all categories adopting BMPs.
   - Complete an assessment of nitrogen loading in the springs basin to identify amount of loading occurring from each land use by end of 2012.
   - Use the assessment of loading to prioritize land uses that need the adoption of BMPs as well as other mitigation strategies.

9.6 Water Quantity (Spring Flow)

Unpublished data gathered by both the SWFWMD and the USGS indicate that there has been some measurable decline in flow at the Rainbow Springs Group over the previous decade. However, flows do appear to have remained within the range of historical flows (see **Figure 4-11**). The groundwater divide between the Rainbow and Silver Springs basins is not well defined due to a flat hydraulic gradient within the Upper Floridan aquifer (UFA) in central Marion County and limited monitoring wells in the area. There are indications that the groundwater divide between Silver Springs and Rainbow Springs may now be moving east, increasing the size of the Rainbow Springs basin. Ongoing work at the SJRWMD as well as associated work with setting MFLs for both springs is further examining this question (SJRWMD, unpublished data presented at Silver Springs Basin Working Group meeting. Nov, 2010).

According to the Marion County Water Resources Assessment and Management Study (WRAMS) (Water Resources Associates 2007) published in 2007, Marion County residents used 196.5 gallons of water per capita per day (gpcd). This was almost double the statewide average of 105 gpcd. Marion County does have a lot of internally drained, high infiltration soils with a deep water table. This situation would tend to allow more water for lawn and landscape irrigation then more poorly drained soils under shallow water table conditions and may explain part of the high per capita use. Of the total use of water in the county, 69.13% was reported as potable uses (combined from public supplies and domestic self-supply (wells). Of the remainder, almost 20% was for agriculture, almost 9% for recreation, and about 2.5% for commercial, industrial, and mining uses. A total of 86.5 mgd was used in 2005, the year that these estimates were made for the report. These percentages together with estimates of the actual amounts of water used are summarized in **Table 9-4** below.

Table 9-4. Water Use Estimates by Use Category

Water Use Type	Water Use Estimate for 2005 (MGD)	% of total County Estimate
Public Supply and Domestic Self-supply	59.8	69.13%
Agriculture	17	19.65%
Recreation	7.4	7.40%
Commercial, Industrial and Mining	2.3	2.30%
Total	86.5	100%

Source: Marion County Water Resources Assessment and Management Study

A more recent data set was obtained from the Detailed Water Supply Feasibility Analysis which was done for the Withlacoochee Regional Water Supply Authority (WRWSA) (Water Resources Associates 2010). Using the same base year as the WRAMS, 2005 public supply was listed as 30.13 mgd, and domestic self-supply 20.62 mgd for a total of 50.75 mgd. Marion County used baseline water use data for 2005 that was higher than actual use reported by the SJRWMD and SWFWMD with the difference between the two data sets being 15.1%. Data from the WRWSA

report for Marion County are presented in **Figure 9-6** showing the same usage categories as WRAMS with a total daily usage for 2005 given as approximately 67 mgd (19.5% lower than WRAMS estimates). The major discrepancy appears to be in the estimation of water for agricultural uses. WRAMS estimated 17 mgd for 2005, and WRWSA estimated only about 6 mgd. The estimates for future agricultural use are also very different.

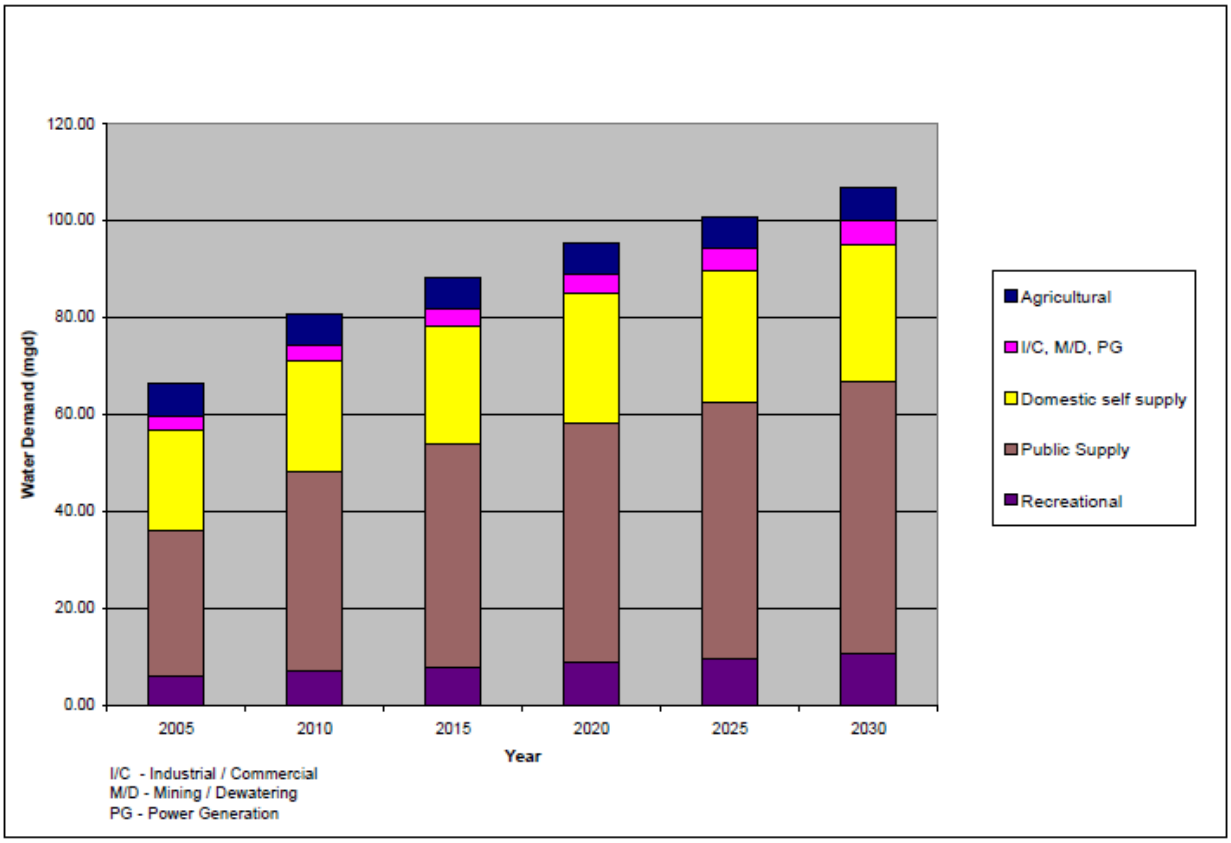


Figure 9-6. Incorporated and Unincorporated Marion County Projected Water Demand
Source: Water Resources Associates 2010

The SWFWMD has mandated that all public supply utilities within their jurisdiction meet a per capita of 150 gpd/person by 2018. This would include Marion County, west of I-75.

Almost 98% of Marion County's potable water supply is obtained from the Floridan Aquifer, the same source that supplies Rainbow and Silver Springs. Surface water augments agricultural irrigation, and an estimated 2.1 mgd was reported in the WRAMS representing about 3% of the county's total water supply. Reuse water is collected and used to augment irrigation on golf courses, residential and commercial landscapes, and some agriculture by Ocala, Belleview, On Top of the World, Dunnellon, and Marion County. The total amount of reuse water by the utilities listed above was 9.27 mgd in 2005 representing almost all the available, centrally collected wastewater.

The WRAMS attempted to predict future demand for a public water supply based upon a combination of projected population growth to 2055 and estimates of decreasing per capita use

due to the implementation of conservation measures. The 2055 population was predicted to be between 615,500 and 966,750. Metered public supply systems create opportunities for measuring per capita water use that are not normally available for domestic self-supply (private wells). Through alternative, widely accepted methodologies, water use for domestic self-supply can be estimated. Additionally, nonpotable uses of water were also projected to 2055 using water management district data. The projections yielded the data shown in **Table 9-5** and indicated a predicted rise in the proportion of the water supply that will need to be potable.

Table 9-5. Future Water Use Projections by Use Category

Water Use Type	Year 2055 Estimate (MGD)	% of total County Estimate
Public Supply and Domestic Self-supply	168.3	83.07%
Agriculture	16.0	7.9%
Recreation	14.3	7.06%
Commercial, Industrial and Mining	4.0	1.97%
Total	202.6	100%

Source: Marion County Water Resources Assessment and Management Study

Predictions for future demand in Marion County according to WRWSA (Water Resource Associates 2010) are shown in **Figure 9-6** up to 2030. Total use is predicted to be about 106 mgd, substantially lower than the projections in WRAMS (interpolated from the 2005-2055 trajectory to be 144.5 mgd). Potable and domestic self-supply are projected by WRWSA to need about 86 mgd by 2030 (**Figure 9-6**), whereas an interpolation of the WRAMS data in 2030 indicates a need for 114 mgd for the same uses.

The WRAMS also compared future water supplies to the projected demand. Limits on groundwater supply were encountered based upon projected effects to the flow of Silver Springs, considered the most sensitive of the larger springs due its proximity to major growth areas of the county. Based on the SJRWMD North Central Groundwater Flow model, it was determined that when total demand for water reaches 110 mgd, there would likely be a direct effect on the flow of water from Silver Springs. Based on the projections of demand, this level of demand will likely occur long before 2055. It was therefore concluded that future demand, as projected, would cause "significant harm" to Silver Springs, assuming continued heavy reliance on groundwater. Under these circumstances, caution should be applied to future water supply planning for all Marion County springs, including the Rainbow Springs Group.
The WRAMS process also examined alternative supplies including surface water (primarily the lower Ocklawaha and lower Withlacoochee rivers) and reuse water with conservation programs in place designed to reduce demand. The supply of reuse water was projected to reach 25to 30 mgd by 2055 from 9.27 mgd in 2005. This does not include new technologies becoming more widely available to capture new sources of reuse water. Reuse water has great potential to lower

demand for groundwater for nonpotable uses. Stormwater also has some potential to be captured and reused for nonpotable purposes.

The WRWSA report (Water Resource Associates 2010) analyzed the potential impact for new well fields in northern Marion County, each predicted to withdraw 15 mgd. (**Figure 9-7**). The possible impact of the northwestern well field on flow from Rainbow Springs was modeled using the SWFWMD ND (Northern District) model and the result was a negligible impact of less than 0.2% of predevelopment discharge rates (**Figure 9-8**). The modeling was based on a 2030 high withdrawal simulation based upon the highest likely population and per capita water usage. Analysis using the SJRWMD NCF (North Central Florida) model revealed a possible 2% reduction in flow at Rainbow Springs by 2030 from 1995 levels. Interestingly the northwestern well field was predicted to have a greater impact on Silver Springs than Rainbow Springs despite its location being several miles west of I-75 and therefore clearly within the boundary of the delineated Rainbow Springs basin (**Figure 4-2**).

Conservation programs have the potential to lower demand through some combination of watering restrictions, pricing incentives, metering, structural measures (e.g., low flow fixtures and xeriscaping), and education. There is limited conservation in place at the time of this writing: non-enforced watering restrictions (water management districts), a water conserving rate structure in the City of Ocala, and some education efforts by the Ocala, Marion County, and water management districts. The fact that Marion County residents use almost double the per capita statewide average indicates a lack of effectiveness of conservation programs at this time but also indicates a high potential for savings in the future.

The WRAMS projected conservation lowering the Marion County per capita use rate to 138 gpcd, a reduction of 58 gpcd or a 30% reduction in per capita demand. While this is an ambitious goal, the per capita water use in Marion County in 2055 would still be 33 gpcd higher than the statewide per capita water use in 2005. Perhaps a more aggressive and successful campaign can lower per capita water use still further.

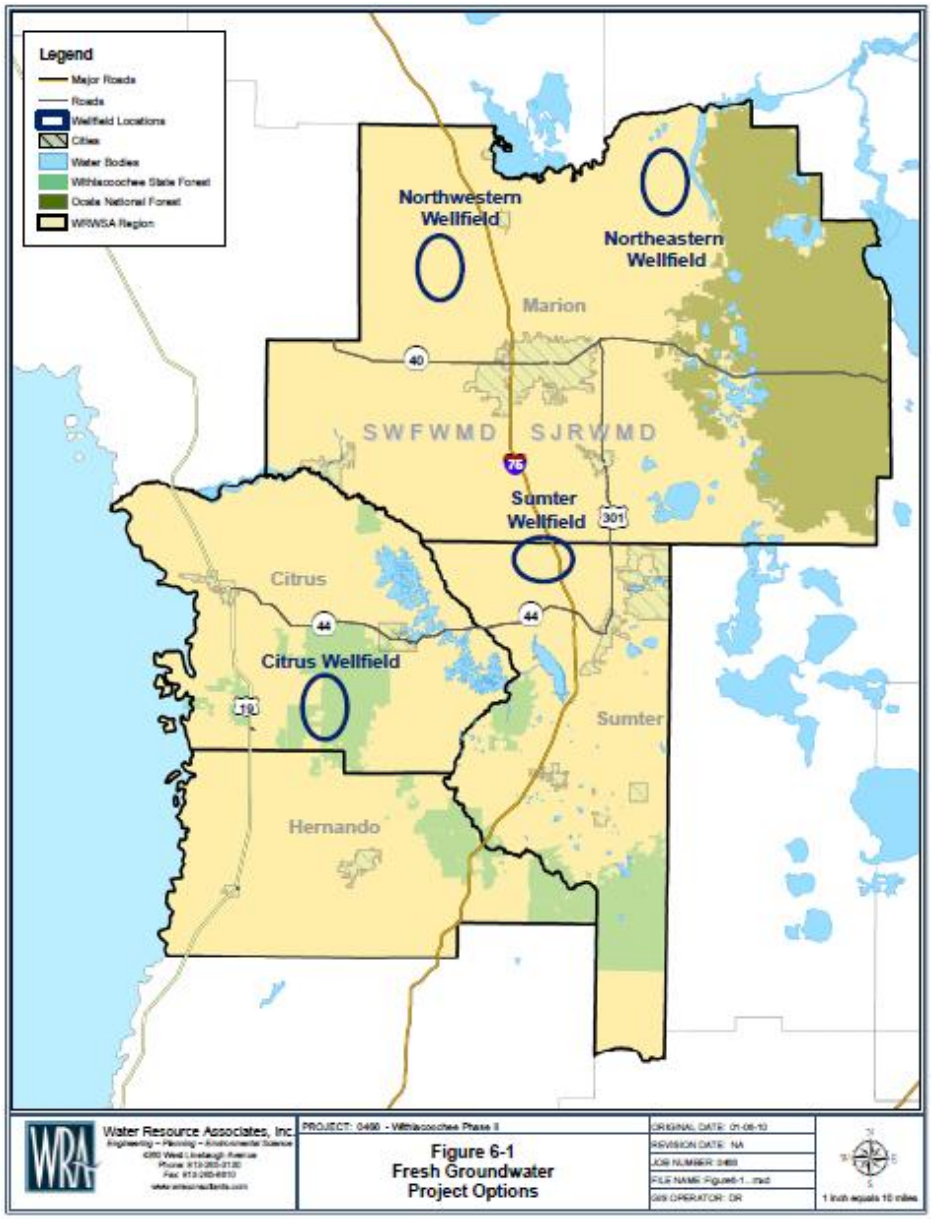


Figure 9-7. Locations of new wellfields planned within Marion and Citrus counties.
Source: Water Resource Associates, 2010.

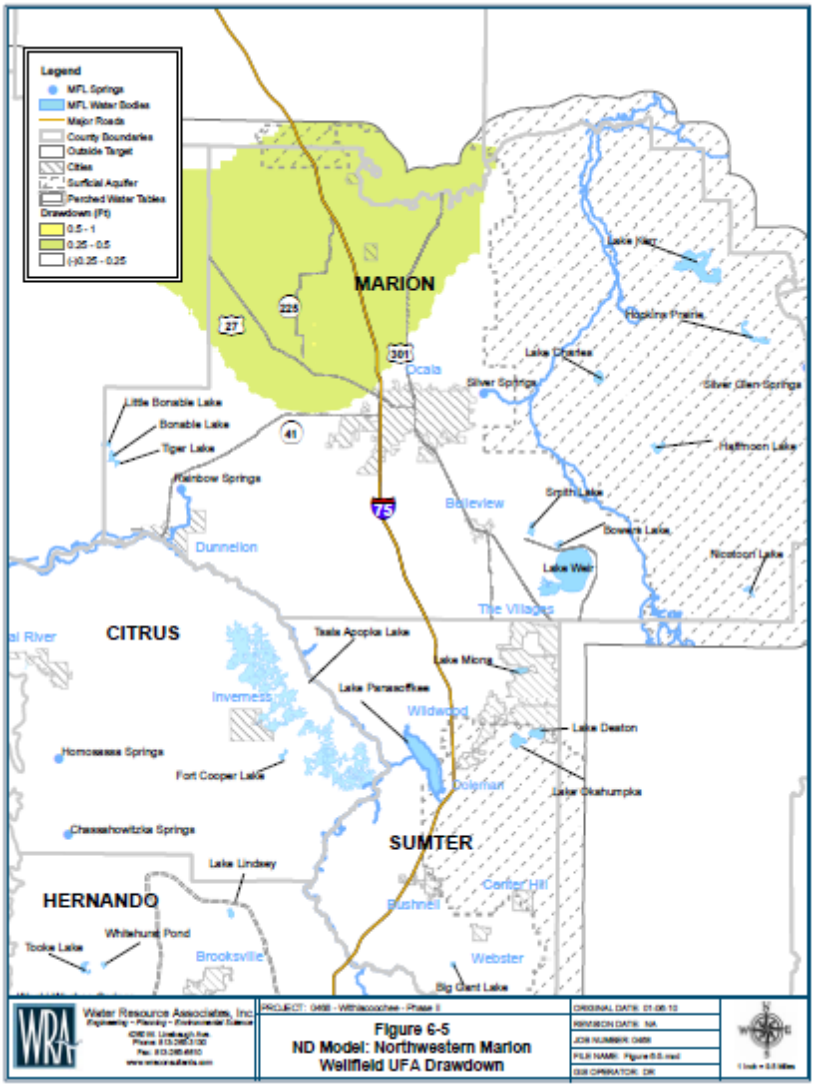


Figure 9-8. Projected drawdown of the Floridan Aquifer System by the proposed Northwestern Marion Wellfield.
Source: Water Resource Associates, 2010.

Goals

1. Implement and/or enforce all existing regulations to protect spring flow quantities.
2. Develop and implement local government initiatives that achieve water conservation.
3. Improve understanding of hydrogeology and flow of Rainbow Springs.

Goals with Suggested Actions

1. Implement and/or enforce all existing regulations to protect spring flow quantities.
    - Set a MFL for Rainbow River by December 2011 that will protect the important biological and recreational resources present in the river throughout all seasons of the year.
    - Carefully scrutinize all new and existing water permits applied for after the MFL is established to ensure they will allow the river to remain within the MFL.

- Consider updating the existing comprehensive regional water supply plan for the Northern Planning Region (WRWSA) of the SWFWMD (encompassing Rainbow River) after the MFL is established to ensure that the MFL becomes central to water supply planning.

2. Develop and implement local government initiatives that achieve water conservation.
   - Encourage building codes that promote water conservation.
   - Identify how future water needs at the county level will impact Rainbow River.
   - Identify opportunities for and then promote the use of reuse water.
   - Explore alternative water sources.
   - Update existing and develop new educational programs for water conservation.
   - Retrofit existing water lines to accept reuse water where possible.
   - Discourage the introduction of water bottling plants in the Rainbow Springs basin.
   - Develop and promote xeriscape and/or native landscaping and irrigation ordinances.
   - Promote Marion County's Best Management Practices for the Green Industry certification program.
   - Support efforts to better determine how much water is being withdrawn by domestic self-supply.
   - Establish partnerships within the Marion County builder/developer community. For example, conduct a workshop series on water conservation for the Marion County Building Association.
   - Develop irrigation audit/leak detection programs for homeowners.
   - Promote low-impact development practices within the springs basin.

3. Improve understanding of hydrogeology and flow of the Rainbow Springs Group.
   - Maintain the present level of monitoring of the spring flow and increase monitoring effort if future needs arise.
   - Determine climatic and seasonal variability of flows and adjust water needs accordingly.
   - Encourage the re-establishment of previously impacted wetlands in the springs basin.
   - Protect areas of high recharge from modifications that will decrease the recharge capability.
   - Implement a study to improve understanding of conduit flow in the springs basin and the relationship of conduits to karst features (sink holes and swallets) on the surface.
   - Develop a new groundwater model for the Rainbow Springs basin that can be used by both water management districts for more accurate assessments of future water supply.

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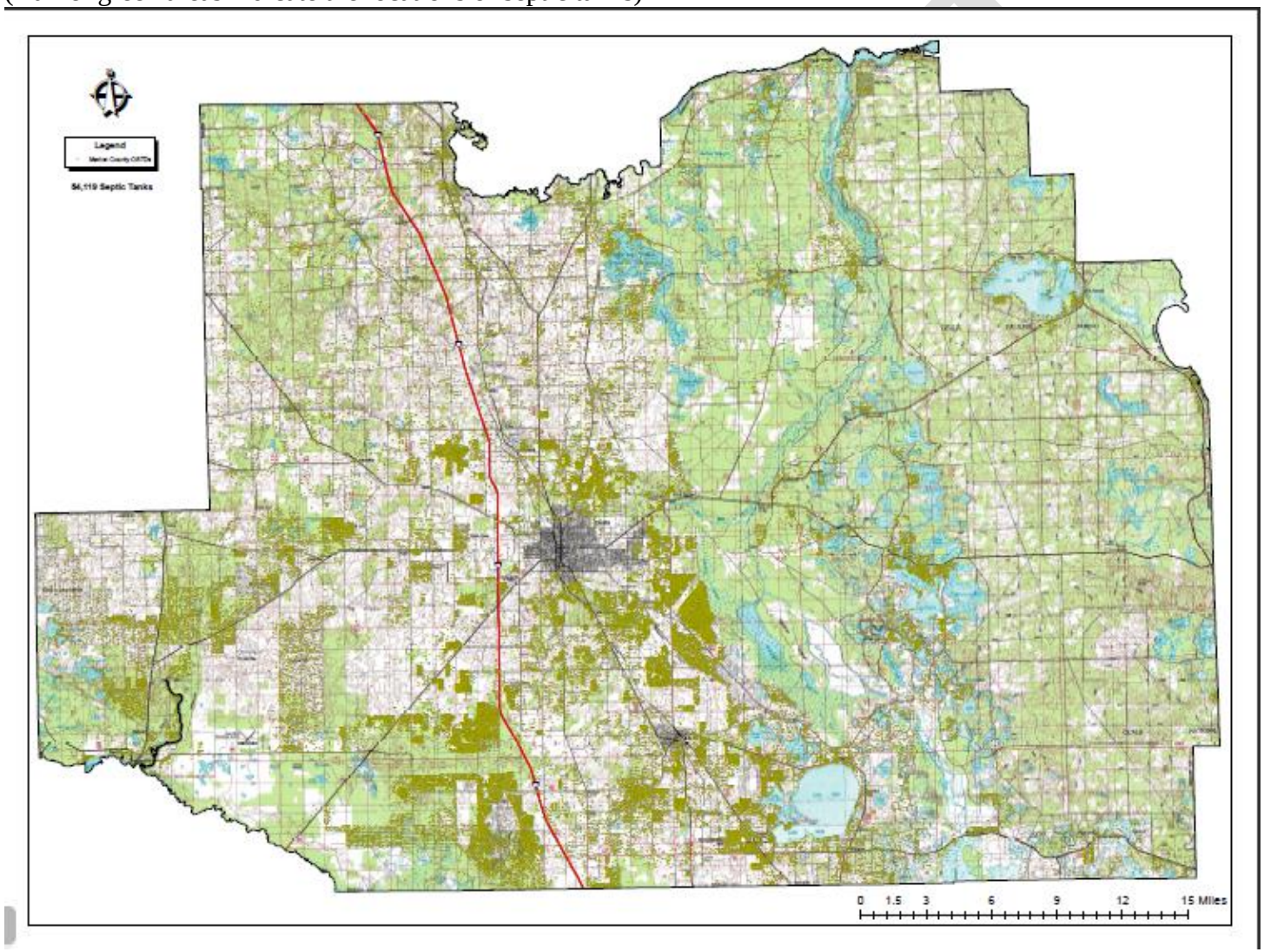
11 Appendices

Appendix A. Location of Onsite Sewage Treatment Systems in Marion County

Source: Marion County Utilities

(Darker green areas indicate the locations of septic tanks)



Appendix B. Nitrate Loading Estimates for Rainbow Springs

Source: SWFWMD Draft Data

The five figures below are based on calculations done by staff at SWFWMD and are provided as a courtesy to the Restoration Plan.

Appendix C. Goal and Action Worksheets for Restoration of Rainbow Springs and River

Working Group members were divided into teams and provided worksheets upon which to record goals and actions as they were created. These sheets are presented below and include who would be responsible for each action, when it should be done by, resources needed to accomplish the action and how the successful completion of the action would be evaluated.

These sheets represent a work in progress with some groups advancing further than others. They represent recommendations and can act as a starting point for discussion to implement the restoration plan.

The goals and actions are presented in alphabetical order as follows:

Biodiversity
Education and Outreach
Land Use and Development
Recreation
Water Quality
Water Quantity

Biodiversity: Actions

Goal: Restore the diversity and quantity of native flora and fauna in the Rainbow River system.				
Action	Who	When	Resources Needed	Evaluation
Conduct flora inventory	DEP or SWFWMD – contracted to NGO or university	When funding available	Funding	Final Report – Updated 1985 Rainbow River Management Plan plant survey
Conduct faunal inventory	DEP, SWFWMD, FWC	When funding available	Funding	Final Report
Compare results of 1994 vegetation/recreation study conducted by UF with 2011 study currently underway	UF and DEP	2012	Staff time	Completed Analysis
Implement use of zoning in the river to protect biodiversity	DEP, FWC, Marion County, City of Dunnellon	Upon adoption of the restoration plan	Funding, Staff time, public buy-in, appropriate regulations	Study to determine if protected areas are sustained or recovered
Identify species in need of specific management actions	DEP, FWC	After flora and faunal inventories are completed	Staff Time	List of species, Identified actions.

Biodiversity: Actions

Goal: Reduce and control invasive exotic flora and fauna in the Rainbow River system.				
Action	Who	When	Resources Needed	Evaluation
Inventory location and extent of exotic and invasive species	DEP, SWFWMD, FWC	Ongoing	Continued funding, staff	GIS maps
Develop invasive/exotic treatment plan for Rainbow River	DEP, FWC	Ongoing	Funding, staff	Yearly work plans
Develop invasive exotic education and enforcement program targeting river access locations	DEP, FWC	Upon completion of the management plan	Funding	Developed program
Research potential solutions to remove or control Lyngbya	UF	Ongoing	Funding	Field and laboratory studies. USDA approved control methods

Education and Outreach: Actions

Goal: Educate stakeholder groups on ways to improve the water quality in the Rainbow Springs Basin.				
Actions	Who	When	Resources needed	Evaluation
Inventory existing education programs to identify possible overlaps and new programs needed.	SWFWMD, SJRWMD, MC, Municipalities	By end of 2011	Staff time and facilitator	Complete a report.
Maintain existing educational efforts; Clean Farms, teacher trainings, Know Where it Flows.	SWFWMD, MC	Ongoing	Funding and staff time	Pre and Post tests and number of successful programs
Create a specific curriculum (designed to meet Sunshine State Standards) for the Rainbow Springs Basin for schools.	SWFWMD	By end of 2014	Funding and either staff or a contractor.	Getting the curriculum created. Assess usage and test knowledge gained by students.
Create neighborhood programs promoting landscape BMPs, specifically for fertilizer use.	SWFWMD, MC	By end of 2012	Neighborhoods and volunteers plus funding and staff time	Number of programs, pre and post-tests plus # of people who intend to change behaviors. Follow-up to see if behaviors do change.
Coordinate a forum for decision-makers on the economic impacts of poor water quality vs. improved water quality	SWFWMD, SJRWMD, MC, Municipalities	By end of 2012	Funding and staff time	Complete the program. Observe future actions of participants.

Land Use and Development: Actions

Goal: By 2020, ensure all jurisdictions within the Rainbow Springs basin shall offer density bonuses for cluster development as well as for "purple pipe" systems and gray water systems.				
Action	Who	When	Resources needed	Evaluation
Marion County will add this to their comp plan if not already there. Then add to LDRs.	MC Planning	2020	None	
Levy County will add this to their comp plan if not already there. Then add to LDRs	LC Planning	2020	None	
Dunnellon will add this to their comp plan if not already there. Then add to LDRs	City of D Planning	2020	None	
Williston will add this to their comp plan if not already there. Then add to LDRs	City of W Planning	2020	None	

Land Use and Development: Actions

Goal: By 2020, all developments within ½ mile of the Rainbow River and Spring will be on municipal water and sewer systems				
Action	Who	When	Resources needed	Evaluation
Assess current situation and identify all properties within the ½ mile buffer on septic and well vs. municipal water and sewer systems				
Develop plan to implement the needed hookups				
Seek funding necessary to implement the needed hookups				

Land Use and Development: Actions

Goal: Implement regulations by 2020 to ensure all high density developments within the spring basin are connected to a wastewater treatment system, preferably with advanced treatment.				
Action	Who	When	Resources needed	Evaluation
Marion County will add this to their comp plan if not already there. Then add to LDRs	MC Planning	2020	None for planning. $ needed for hookups and new WWTPs	
Levy County will add this to their comp plan if not already there. Then add to LDRs	LC Planning	2020	None for planning. $ needed for hookups and new WWTPs	
Dunnellon will add this to their comp plan if not already there. Then add to LDRs	City of D Planning	2020	None for planning. $ needed for hookups and new WWTPs	
Williston will add this to their comp plan if not already there. Then add to LDRs	City of W Planning	2020	None for planning. $ needed for hookups and new WWTPs	

Recreation: Actions

Goal: Protect the aquatic resources of the Rainbow River system while promoting sustainable recreational uses.				
Action	Who	When	Resources needed	Evaluation
Educate user groups about the fragile ecosystem they use	All public access points	Daily	Videos, brochures, interpretive displays, etc.	Repeat the UF study of 1994 and 2011 on a five year cycle
Determine a carrying capacity for users of the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon & Villages of Rainbow Springs POA	September 2012	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Develop a management plan for recreational use of the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Examine opportunities to use spatial and temporal zoning to reduce recreational impacts to the aquatic community of the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Develop strategies to reduce user conflicts on the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Examine commercial use of the river both levels of use and any impacts to the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle

Goal: Protect the aquatic resources of the Rainbow River system while promoting sustainable recreational uses.				
Action	Who	When	Resources needed	Evaluation
Determine if there is sufficient quantity and quality of public access to the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Examine the impacts specific to the wildlife associated with the river	DEP, Marion Co., WMD, FWCC, City of Dunnellon	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle
Survey visitor experiences on the river to determine level of user comfort and satisfaction	DEP, Marion Co., WMD, FWCC, City of Dunnellon, UF	March 2013	UF Study and SWFWMD Vegetation Survey of 2011	Repeat the UF study of 1994 and 2011 on a five year cycle

Water Quality: Actions

Goal: By 2016, halt the increasing trend in nitrate concentrations in the Rainbow River Springs Group that is present in 2011.				
Action	Who	When	Resources needed	Evaluation
Encourage farmers to develop and embrace nitrogen reduction strategies and Nutrient Management Plans Enroll at least 10 agricultural landowners per year operating within the spring basin into an appropriate BMP program)	FDACS, FDEP IFAS and County Extension Service	now		
Establish nitrogen TMDL and initiate a Basin Management Action Plan for the basin	FDEP, EPA	now		
Implement the Marion County Watershed Assessment Model (WAM)	County and state	now	requires detailed analysis of current land use and land cover data coupled with water quality data	
Identify areas of localized high groundwater recharge, closed depressions, sinkholes and swallets, that may provide rapid transport of nutrients and other pollutants to springs	Academic groups, karst researchers, County, FDEP, WMD, caving and cave diving community	now	Karst feature inventory and mapping, dye trace studies	
Reduce loading contributions from septic tanks with responsible maintenance, inspections, improved technology, and retrofits	Homeowners, State and county, FDOH	now		
Expand reclaimed/reuse water availability	State and county	within next 5 yrs	New infrastructure, centralized sewers, new wastewater treatment facilities, and upgrades of existing facilities to AWT, transmission lines for reuse water	

Goal: By 2016, halt the increasing trend in nitrate concentrations in the Rainbow River Springs Group that is present in 2011.				
Action	Who	When	Resources needed	Evaluation
Quantify the economic impact of increased nutrients: How much will it cost to do nothing?	Academic institutions, who else?	now		
Provide easily understandable information and presentations on Rainbow Springs and water quality to a wide audience: schools, public officials, the general public		ongoing		
Improve stormwater retention and treatment for nutrient reduction, applied to new systems and retrofit of existing structures	County and State	within next 5 yrs		
Reduce stormwater volumes and nutrient loads in runoff water				
Continued water-quality monitoring and assessment of springs and groundwater in the basin	FDEP, WMD, county	ongoing		

Water Quantity: Actions

Goal: Implement and/or enforce all existing regulations to protect spring flow quantities.				
Action	Who	When	Resources needed	Evaluation
Set a Minimum Flow and Level (MFL) for Rainbow River by Dec. 2011 that will protect the important biological and recreational resources present in the river throughout all seasons of the year.	SWFWMD	December 2011		
Carefully scrutinize all new and existing water permits applied for after the MFL is established to ensure they will allow the river to remain within the MFL	SWFWMD	ongoing		
Update the existing comprehensive regional water supply plan for the Northern Planning Region (WRWSA) of the SWFWMD (encompassing Rainbow River) after the MFL is established to ensure that the MFL becomes central to water supply planning	SWFWMD and WAWSA	2012		

Water Quantity: Actions

Goal: Develop and implement local government initiatives that achieve water conservation.				
Action	Who	When	Resources needed	Evaluation
Encourage building codes that promote water conservation	Marion and Levy Cos. Cities of Dunellon and Williston.			
Identify how future water needs at the county level will impact Rainbow River	Marion and Levy Cos. Cities of Dunellon and Williston.			
Identify opportunities for and then promote the use of reclaimed water and/or reuse treated water	Marion and Levy Cos. Cities of Dunellon and Williston.		Local Utilities	
Explore alternative water sources.	Marion and Levy Cos. Cities of Dunellon and Williston.	ongoing	Local Utilities	
Update existing and develop new educational programs for water conservation i.e., 40 Gallon Challenge (http://www.40gallonchallenge.org/about.cfm	SWFWMD Marion and Levy Cos. Cities of	ongoing	Funding, volunteers	

Goal: Develop and implement local government initiatives that achieve water conservation.				
Action	Who	When	Resources needed	Evaluation
	Dunellon and Williston.			
Retrofit existing water lines for reclaimed water use.	Marion Co.	ongoing		
Discourage the introduction of water bottling plants in the Rainbow Springs recharge basin.	Marion and Levy Cos. Cities of Dunellon and Williston.			
Develop and promote xeriscape and/or native landscaping and irrigation ordinances. Promote Marion County's Green Industry Best Management Practice Certification program	Marion and Levy Cos. Extension. Cities of Dunellon and Williston.			
Support efforts to better determine how much water is being withdrawn by domestic self-supply	Marion and Levy Co. SWFWMD City of Dunellon City of Williston			
Establish partnerships within Marion Co. builder/developer community. For example, put on a workshop series on water	Marion County Extension,			

Goal: Develop and implement local government initiatives that achieve water conservation.				
Action	Who	When	Resources needed	Evaluation
conservation for the Marion County Building Association	Springs Working Group			
Develop irrigation audit/leak detection program for homeowners	Marion County Extension			
Promote Low-Impact Development Practices within spring basin	Marion County Extension			

Water Quantity: Actions

Goal: Improve understanding of hydrogeology and flow of Rainbow springs.				
Action	Who	When	Resources needed	Evaluation
Maintain the present level of monitoring of the spring flow and increase monitoring effort if future needs arise.	USGS	Continuous daily monitoring	USGS gaging stations	
Determine climatic and seasonal variability of flows and adjust water needs accordingly.	SWFWMD			
Encourage the re-establishment of previously impacted wetlands in the spring basin	Marion and Levy Counties Marion Soil and Water	ongoing		
Protect areas of high recharge from modifications that will decrease the recharge capability	Marion and Levy Counties			
Implement a study to improve understanding of conduit flow in the springs basin and the relationship of conduits to karst features (sink holes and swallets) on the surface.	SWFWMD, FGS, Marion and Levy Counties			